DEVELOPMENT OF A DYNAMIC STRATEGY MAP INCORPORATING SCENARIO ANALYSIS AND SYSTEM DYNAMICS: A SIMULATION TEST ON AN INTERNATIONAL CONSTRUCTION COMPANY

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
CIVIL ENGINEERING

AUGUST 2018

Approval of the thesis:

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ABSTRACT

DEVELOPMENT OF A DYNAMIC STRATEGY MAP INCORPORATING SCENARIO ANALYSIS AND SYSTEM DYNAMICS: A SIMULATION TEST ON AN INTERNATIONAL CONSTRUCTION COMPANY

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August 2018, 414 pages

The balanced scorecard (BSC) and strategy map (SM) methods developed by Kaplan and Norton [1] are widely utilized both in academic studies and in practice to measure organizational performance. On the other hand, these methods are criticized in the literature due to their inability in quantifying bi-directional causalities among strategies, aggregating performance measures, reflecting dynamic nature of real-life behavior, and making simulations to understand implications of future scenarios to support strategic decision-making. The aim of this research is to develop a dynamic SM model by incorporating scenario analysis and systems dynamics to enhance strategic planning (SP) and performance management (PM) practices of international construction companies. To develop a dynamic SM model, this research uses BSC and SM methods of Kaplan and Norton [1], future scorecard model of Fink et al. [2] and Systems Dynamics method of Forrester [3] and Sterman [4]. To develop and test the dynamic SM model, this research is conducted in five consecutive phases with the collaboration of one of the biggest Turkish construction companies. Some serial Group Model Building sessions are conducted with the participation of company experts in order to ensure structural and behavioral validity of the model as well as to test whether the model has a potential to enhance strategic decision-making. The simulation tests conducted with the Company revealed that, the model improves the quality of strategic decision-making as it simulates impacts ofalternative strategic options and possible future scenarios on organizational performance. Thus, this research has potential to offer a reliable methodology and a model for scholars and industry practitioners about how to develop dynamic SMs via SD modeling and utilize them during strategic decision-making and PM.

Keywords: Strategic Performance Management, Balanced Scorecard, Dynamic Strategy Map, System Dynamics, Scenario Thinking.

ÖZ

SENARYO ANALİZİ VE SİSTEM DİNAMİĞİ KULLANILARAK DİNAMİK BİR STRATEJİ HARİTASININ GELİŞTİRİLMESİ: ULUSLARARASI BİR İNŞAAT ŞİRKETİNDE SİMÜLASYON TESTİ

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Kaplan ve Norton [1] tarafından geliştirilen kurumsal karne (BSC- balanced scorecard) ve strateji haritası yöntemleri, hem akademik çalışmalarda hem de uygulamada kurumsal performansı ölçmek için yaygın olarak kullanılmaktadır. Öte yandan, günümüz literatüründe bu yöntemler; iki yönlü neden-sonuç ilişkisinin ölçülmesi, ayrı performans ölçütlerinin bütünleştirilmesi, gerçek hayat davranışının dinamik doğasının yansıtılması ve stratejik karar verme sürecinin desteklenmesi için gelecek senaryoların günümüze olan etkilerini anlamayı sağlayan simulasyonlar yapılmasındaki kısıtları nedeni ile eleştirilmektedir. Bu araştırmanın amacı, uluslararası inşaat firmalarının stratejik planlama ve performans yönetimi uygulamalarını geliştirmesi amacıyla senaryo analizi ve sistem dinamiği yöntemlerinin bir araya getirilmesiyle dinamik bir strateji haritası modelinin geliştirilmesidir. Bu araştırmada; Kaplan ve Norton'un [1] kurumsal karne ve strateji haritası yöntemleri, Fink vd. [2] tarafından önerilen gelecek karnesi (future scorecard) ile Forrester [3] ve Sterman [4] tarafından geliştirilen sistem dinamiği yöntemleri temel alınmıştır. Dinamik strateji haritası modelinin geliştirilmesi ve test edilmesi amacıyla, bu araştırma, önde gelen Türk inşaat şirketlerinden birinin işbirliği ile beş aşamada yürütülmüştür. Modelin yapısal ve davranışsal geçerliliğinin sağlanması ve stratejik karar alma süreçleri için yeterince destekleyici olup olmadığının test edilmesi amacıyla şirket uzmanlarının katılmı ile bir dizi araştırma Grup Modeli Oluşturma oturumu yapmıştır. Şirket ile yapılan simülasyon testleri; farklı strateji seçimleri ve gelecek senaryolarının organizasyonel performans üzerindeki etkisinin test edilebilmesi sayesinde modelin, alınan stratejik kararların kalitesini arttırmada faydalı olduğunu göstermiştir. Bu araştırmanın, sistem dinamiği modelleme yöntemi ile dinamik strateji haritalarının nasıl geliştirileceği ve bu haritaların stratejik karar verme sürecinde nasıl kullanılacağı konusunda, hem akademisyenler hem de sektör paydaşları için güvenilir bir metodoloji ve model sunabileceği düşünülmektedir.

Anahtar Kelimeler: Stratejik Performans Yönetimi, Kurumsal Karna, Dinamik Strateji Haritası, Sistem Dinamiği, Senaryo Bazlı Düşünme, Grup Model Oluşturma

To my beloved family...

ACKNOWLEDGEMENTS

The work presented in this thesis would not have been possible without support of many people. I would like to remark my gratitude and appreciation to all those who made this Ph.D thesis possible.

Firstly, I would like to express my sincere gratitude and regards to my advisor Prof. Dr. İrem Dikmen Toker. Without her continuous support, endless patience, and invaluable guidance, this thesis would not have been possible. I have learnt extensively from her so far and feel privileged to be associated with a professor and a mentor like her during my life.

Besides my advisor, I would like to thank Prof. Dr. M. Talat Birgönül for his insightful comments, priceless guidance and encouragement in all the time of this thesis. In addition, I would like to acknowledge my collegues from METU Construction Engineering and Management Division. In particular, I am grateful to Hüseyin Erol and Gözde Bilgin for their invaluable help that served me a lot.

I owe my deepest gratitude towards my beloved family, Selma Yıldız and Zekai Yıldız. Their endless love and unconditional support has always been my strength. I am the luckiest person in life to have such parents.

I would also like to thank my dearest friends; Buse Kurt, Can Kurt, Makbule Ilgaç, Gizem Can, Zeynep Çekinmez, Melek Yılmaztürk, Nagehan Akan, Nil Ciritoğlu, Ayşe Sert, Deniz Köksoy, Itır Özkoçak, Melis Yıldız, Cemre Tanış and Arda Tanış, who continuously encouraged me with their invaluable friendship and motivation throughout my research.

I would like to thank to the Scientific and Technical Research Council of Turkey (TUBITAK), which provided scholarship to me throughout this thesis.

Finally yet importantly, I would like to express my great thanks and gratitude to the Turkish construction company, which supported this research by contributing as a case company. I am grateful to the experts of the company, who shared their valuable knowledge and experience throughout the research.

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LIST OF ABBREVIATIONS

AHP	Analytical Hierarchy Process
ANP	Analytical Network Process
BSC	Balanced Scorecard
CLD	Causal Loop Diagram
CSR	Corporate Social Responsibility
DEA	Data Envelopment Analysis
DEMATEL	Decision Making Trial and Evaluation Laboratory
EFQM	European Foundation for Quality Management
GM	Global and Market Conditions
GRI	Global Reporting Initiative
HBR	Harvard Business Review
JV	Joint Ventures
KPI	Key Performance Indicators
MA	Mergers and Acquisitions
OHS	Occupational Health and Safety
OR	Operational Research
PM	Performance Management
PMBoK	Project Management Body of Knowledge
PMI	Project Management Institute
QFD	Quality Function Deployment
RBV	Resource-Based View
RC	Resources and Capabilities
SAP	Scenario Analysis Process
SD	System Dynamics
SDP	System Dynamics Process
SEM	Structural Equation Modelling
SFD	Stock-Flow Diagram
SM	Strategy Map
SMS	Strategy Map Structure
SOT	Strategic Objectives Taxonomy
SP	Strategic Planning
SPMP	Strategic Performance Management Process
SWOT	Stregnths, Weaknesses, Opportunities, Threats

CHAPTER 1

INTRODUCTION

1.1. BACKGROUND OF THE RESEARCH

Having roots in General Tzu's classic Chinese writings, strategy has come a subject of study in business environments after 1950's. In the 1980s, Michael Porter defined strategy as a competitive advantage term, which further inspired other scholars to elaborate strategy in economics [5]. In different body of research proposed by Henry Minztberg and Andrew Pettigrew, strategy is elaborated in the field of sociology and psychology. After 1980s, a growing body of research is conducted to explore different terms and typologies of "strategy" and the way it was managed in organizational reality. Thus, the literature is rich and diverse in the definition of strategy as it fulfills different managerial objectives in organizations ([6], [7]). In one of the earliest approaches, [8] conceded that strategy is about actions taken by the organizations that lead to changes in them based on the changes in their environment. [5] defined strategy as a way to achieve competitive advantage through relating strategy with economics. [9] elaborated strategy as "a plan, ploy, pattern, perspective, or position based on the managerial intentions of the organizations".

After 1960's the strategy is also elaborated as a "concept" in management science, which is facilitated for defining, controlling and monitoring the intended directions of organizations. The term strategic planning (SP) is born, which is defined as a process to define a road map for an organization that is the organization is intended to follow [10]. It is further transformed into the term of "strategic management" to systematically manage organizational goals. In one of the earliest approaches, [11] defined six steps of a strategic management process; (1) goal formulation, (2) environmental analysis, (3) strategy formulation, (4) strategy evaluation, (5) strategy implementation, and (6) strategic control.

The evolution of the concept of strategic management is also required incorporation of some other management sciences to support its different steps. One of them is the performance management (PM), which has become critical in assessing, monitoring and controlling the way strategies implemented.

PM is firstly undertaken by a firm named, DuPont, in the first quarter of the 20th century by measuring the financial performance through the measure of return on investment (ROI) [12]. Following 1925, many other PM methods and techniques are developed and used in practice (i.e. [13], [14], [15]), which are largely based on measuring financial performance. By 1950s, PM method having focus on financial performance, are become to question due to their inability to reflect soft measures. Since the early 1990s, various scholars have attempted to suggest novel PM methods to overcome some limitations of the early methods. For example, Robert Kaplan and David Norton introduced Balanced Scorecard (BSC) concept in the January- February 1992 issue of Harvard Business Review (HBR) [1]. After its announcement, the attention for BSC has grown year by year, also with the new developments made by its owners on the original BSC.

The initial idea of BSC is to combine financial and non-financial perspectives in a single performance scorecard model. The original BSC includes financial performance measures as well as some operational measures those categorized under three perspectives; customer satisfaction, internal business processes, and innovation and learning. With the use of BSC, it is expected to make organizations to consider both financial and non-financial measures when assessing performance of their organizations. Through the years, Kaplan and Norton have also improved the theoretical foundation of their original BSC ([16], [17], [18], [19]) to exempt their model from serious criticism and create its current worldwide popularity [20]. In this regard, the term "Strategy Map" (SM) is born which has transformed the BSC from a measurement system to a strategic management system. In 2004, Kaplan and Norton announced the method of SM that translates the general strategy statements into specific objectives with which employees can understand and act on [21]. SMs are expected to create the "missing link" between strategy formulation and strategy execution by representing how value is created through cause and effect relationships between diverse strategic objectives [21]. They are regarded as the visual representation of relations among the key components of organizational strategies [22].

The BSC and SM are announced as two of the most influential business ideas of the past 75 years [20] by HBR and reported to be used by 40% of the Fortune 1.000 companies at the end of 2001 [23]. The popularity of them has also spread to the construction industry, indeed the study of [24] demonstrated that 24,5% of UK-based construction engineering firms surveyed by the authors have adopted BSC. They have a significant presence both in worldwide [25] and in the construction management literature [20] as powerful communication tools for PM. As claimed by [26], although there is no definite empirical evidence to confirm that adopting the BSC truly leads to superior performance, anecdotal evidence shows that the popularity of BSC is growing in a variety of applications. As reported by [20], the major strengths of the BSC and SM are as follows,

- They incorporate four performance perspectives (financial, customer, internal process, learning and growth) in one simple and easy-to-use management report ([27], [15]).
- They explicitly highlight causalities among performance measures, which make the PM process as a feedforward control system [28].
- The linkage between performance measures and organizational strategies makes SM, as a strategy control system, which is a weak area of many organizations [29].
- They contain both outcome measures (lagging) and the driver of the outcome measures (leading) ([30], [31], [29]) which enables to understand the cause-effect relations between the measures.

1.2. PROBLEM DEFINITION

Although BSC and SM are two of the most widely utilized methods for SP and PM, they also suffer from some highly criticized limitations. First, they are limited in incorporating organizational and socio-environmental rooting of the organizations [32] and neglect the effect of organizational and environmental factors on the organizational performance [33]. Second, although they consider non-financial indicators, the methodology for defining and assessing non-financial indicators still inherent ambiguity due to their qualitative nature [12]. Third, they are inadequate to identify relative importance of and the trade-offs between performance measures. The consideration of relative importance among measures is also highly critical especially when targets of different measures conflict with each other or when diverse measures require similar resources or competencies ([33], [34], [35], [36], [37], [29]). Finally, they provide little empirical work about how the causalities among measures could be constructed, assessed or managed ([32], [38], [39], [33]). Indeed, any missing link or cause-effect relationship might lead invalid assumptions in a feed-forward control system, which in turn causes individual companies to anticipate faulty performance indicators, resulting in dysfunctional organizational behavior and flawed performance [30].

There also exist some other limitations when the BSC and SM are applied in the construction industry. Most of the PM efforts in the construction industry are focused on the measurement of project performances and limited in the evaluations at a corporate level (i.e. [40], [41], [42], [43], [6]). Thus, applications of the BSC are mostly limited, as the measures of the project-level BSC could not be aggregated into an overall corporate scorecard [16]. In addition, the original BSC is limited when it is applied specifically to an industry. As also suggested by Kaplan and Norton, BSC should be modified based on the country, business or industry where company operates [16] to ensure adequacy of BSC and fully facilitate its benefits ([44], [45], [46], [47], [48], [20], [12]).

In addition to aforementioned limitations, both the BSC and some other PM methods are incapable of incorporating future thinking in the measurement models. According to [49], development of a long-term strategy for an organization needs an expression of a vision including future conditions. This is particularly important when the defined strategy will be utilized for transition of the organization from its current position to a desirable but uncertain and complex future state [18]. Thus, thinking about future during the process of strategy formulation is critical [50]. In this regard, despite of their benefits, traditional BSC and SM have a “static” nature, as they are limited in reflecting any changes in current or future state of organizations. However; relying on static SMs means to “assume not only that the organization and its strategy will stay the same, but also that competitors will continue to behave in the same way”, which limits SMs to reflect evolution of strategy over time ([51], [50]). In addition, these traditional methods are incapable of analyzing past data to predict future states as they do not include possible time lags among performance measures and ignore relationships among future states and conditions ([51], [50]).

1.3. AIM AND OBJECTIVES OF THE RESEARCH

This research argues that, a novel PM method or a model is needed, which overcomes the major limitations of current PM methods reported in literature, in order to enhance SP and PM practices of the construction industry. This model should reflect some characteristics to fully realize benefits of conducting SP and PM. First, the model is expected to provide a comprehensive framework that incorporates internal and external environmental conditions of companies in their SP and PM practices. Second, the model should be used as a company-level system that portrays broader business strategies formulated at the business level [6]. The model should also offer a novel BSC that reflects industry-based characteristics in PM practices via both financial and non-financial measures as well as aggregating these measures in order to quantify an overall performance. The model should also deliver a visualization and quantification method in order to consider relative importance and bi-directional relations among performance measures as well as balance strategies in accordance. It should also convey a control mechanism that portray strategic relevancy of performance measures and truly measures what will be measured.

In addition to the above-mentioned features, a mechanism is needed to support and guide management decisions [45], unless otherwise there is a risk of confusion, failure to use, or interpretation difficulties in PM practices. In addition, subjectivity involved in decision-making due to cognitive biases of the decision makers, should somehow be handled. Thus, the link between the use of SM and decision-making process should be clarified to overcome making arbitrary interpretations and to minimize the effect of dependence on individual mental models when correlating individual measures and map elements [52]. Finally, the model should also incorporate simulation capabilities to enhance the quality of decisions made by making clear of dynamic behavior of the strategies, training in strategy making and supporting actual process of strategy making [53]. Thus, there is a need for explicit and process-based descriptions about how to manage strategic uncertainty [54] as well as how to predict future trends and advances, particularly in the turbulent business climate [2]. This situation rises the need of incorporation of scenario analysis in the field of strategy.

The attention for scenario analysis and planning has also been growing in current literature, both in its methodological approaches or incorporation of some other management techniques including SM (i.e. [55], [56], [57], [58], [59]). In one of the earliest studies on scenario analysis, [59] proposed that scenario analysis encourages managers to evaluate situations that “challenge their current way of thinking and to consider what could be presently unthinkable”. According to [58], different from traditional forecasting techniques, scenario analysis is about encouraging managers to pose questions rather than providing answers about future states. [2] added that; through conducting scenario analysis, organizations oppose the idea that there exists a single predictable future. Thus, scenario analysis provides continually enlarging and discussing the range of possibilities, that enables SP as a collective learning tool [56]. [60] added that with the development of scenarios, managers can enhance SP by minimizing risk posed by future uncertainties, exploiting the trends and opportunities and maintaining risk within an tolerance level. As scenarios enable structured frameworks to develop and analyze corporate strategies, they become a notion of a 'test drive' of strategic decisions [61].

According to [60] and [50] the combination of strategy maps and scenario analysis has a number of advantages;

- SM and scenario analysis provide means to communicate the present and future strategy of the organizations.
- Both methods are developed based on a holistic view of organizations and their internal and external environments.
- The internal focus of SM can be supported by focus of scenario analysis on the conditions of external environment.
- Both qualitative and quantitative aspects of organizations can be considered through SM and scenario analysis.
- Both tools require the participation of numerous stakeholders that contributes to enhance the validity and robustness of the organizational strategies.
- The development of SM and scenarios also denote the comparison of mental models [62] and reaching of inter subjective agreement amongst participants.

Despite the advantages of incorporation of scenario analysis with SM (as reported in [62], [63], [60], [2], [56], [21], [64], [51], [50]), the joint use of these methods is still not common. The studies focusing on scenario-based SMs are poor in description of the actual design process [50], which leaves the combination of the two, largely unexplored. However, that kind of joint use of scenario analysis and SM is especially critic in construction industry as the industry is "predominantly short-term and reactive in their outlook" as well as has to respond changes in its business environment quickly [61].

This research argues that, a novel "thinking philosophy" is needed to elaborate the strategy in diverse outlook and to incorporate scenario analysis and SM. In addition, a "modelling technique" is needed to transform this "thinking philosophy" into practice. In this regard, scenario management theory developed by [2] provides a theoretical basis for that kind of "thinking philosophy". Authors suggest incorporating "Systems Thinking", "Future-Open Thinking" and "Strategic Thinking" in order to develop "future scorecards" for the organizations. As described by [2], "Future-Open Thinking" is about making predictions of future trends and developments by projecting current-state to the future. It is about acceptance of uncertainty in the corporate environment and detection of alternative possible developments. Second, "Strategic Thinking" is about identification of prerequisites of future success potentials as a basis for development and implementation of visionary strategies. Finally, "Systems Thinking" provides organizations to handle increasing complexity, diversity and dynamics in the organizational environment by dealing with interconnections in the system [65]. According to [2], while "Strategic Thinking" combined with the "Future-Open Thinking" will lead to "Scenario Planning", "Systems Thinking" joined with the "Strategic Thinking" will lead to "System Dynamics". Thus, through premising these "thinking philosophies", dynamic SMs can be developed that can successfully respond the changes occurred in the business environment and that can systematically solve complex, nonlinear and dynamic strategic decisions of real life.

System Dynamics (SD) is founded in the 1950s by Jay Forrester who is a professor from Massachusetts Institute of Technology (MIT). The foundations of SD is based on the philosophy of "Systems Thinking" ([3], [62]), which is about ability to understand that "everything is connected to everything else' ([62], [66]) in a dynamic and complex system. "Dynamic Complexity" introduced by [66] is another term used to explain real life systems which are dynamic, complex and interconnected. As criticized by [66], despite the dynamic complexity of real life systems, people tend to make decisions using mental models that are static, narrow and reductionist, as the complexity of the environment exceeds their ability to optimize.

SD is a method for modelling and testing formal mathematical models and computer simulations of complex, nonlinear, and dynamic systems [4]. It is utilized especially in economic, environmental and social systems where a holistic view is crucial and feedback loops are necessary to capture the relations among diverse variables [3]. It is also used to understand how organization and policy development affect organizational behavior over time [67]. Furthermore, it can be utilized to create scenarios that are akin to a real life problem [68]. They can also be used to capture differences in resource accumulation strategies among competing firms as well as to develop resource maps by stimulating the resource profiles and investment strategies of these firms through eliciting mental models of top managers about their firms' conceptual representation ([69], [70]).

1.4. PROCEDURE

This research argues that there is a need for novel strategy mapping model to increase effectiveness of SP and PM practices of the construction industry. In addition, a novel "thinking philosophy", which incorporates scenario analysis and SM methods, is needed in order to enhance quality of strategic decisions made by industry practitioners. In this regard, the aim of this research is to develop a dynamic SM model by incorporating scenario analysis and systems thinking to enhance SP and PM practices of international construction companies.

For conceptualization purposes, this research uses BSC and SM methods of Kaplan and Norton. These methods are taken as reference point; since, as rather than developing a novel or a stand-alone model, it is better to revise some existing models to make them more applicable and suitable [20]. In addition, this research elaborates BSC as a system of measures as well as uses SD method to quantify and computerize this system as it mathematically models and simulates complex, nonlinear, and dynamic systems. With SD method, it is aimed to solve major limitations of the current literature about aggregation, quantification and simulation of BSC measures having "dynamic complexity" in their nature. In addition, based on the scenario management theory of [2], this research aims to present how the future scorecard of organizations can be developed, those enable industry practitioners to envision future performance of their organizations from today by making simulations via dynamic SMs.

As suggested by various authors (i.e. [71], [62], [72], [73], [74], [67], [75]), this research proposes a two-stage method to convey SD modelling ad develop a dynamic SM model. The first stage, qualitative modelling is about development of the causal-loop diagram (CLD) of the model, which is described as Conceptual Model throughout the research. Second is the quantitative modeling, which is about transforming CLD into a stock-flow diagram (SFD), having components of system, feedback, level and rate. Quantitative modeling is referred as Computerized Model, which is developed based on the Conceptual Model. Throughout the development of both models, the SD-modelling process offered by [4] is taken as basis. The process, referred to as System Dynamics Process (SDP), describes the way to conceptualize, formulate, test and simulate SD models, which is dynamic SM.

SDP is conducted in four consecutive steps. “Conceptualization” step is the first step for the development of the SD model. It is about identification of “system” parameters representing BSC measures as well as development of the system interactions, which show bi-directional relations among measures in SM. To do so, CLD is used to conceptualize the dynamic hypothesis of SM and describe the causal relationships among BSC measures. “Formulation" is the second step of the computerization of “Conceptual Model” in a software environment. To do so, CLD is extended and converted into a STD model in order to test and simulate the SM. STD is developed and computerized via a software tool, named Stella Architecture of isee Company. “Testing” is the third step undertaken to verify and validate the “Computerized Model” developed by Stella Architecture. To do so, numerous verification and validation tests are undertaken to ensure both structural and behavioral validity. The final step is the “Simulation”, in which two separate tests are undertaken with a Turkish construction company to understand the behavior of the Computerized Model in real life practices. First, a Scenario Testing is conducted to elicit dynamic behavior of the model under diverse future scenarios. Second, a “Strategic Options Testing” is undertaken to understand the effect of changes in resources and capabilities to the overall strategic achievement.

Although SDP provides a theoretical foundation for how to develop SD-models, another process is also needed that answers the questions of how the owners of these SD-models can use them in their SP practices. Thus, as a further approach, a Strategic Performance Management Process (SPMP) is developed based on the work of [53], which describes how to conduct SP and PM with using such SD-models. The process suggests a four step approach namely, 1) Strategic Positioning, 2) Strategy Formulation, 3) Strategy Implementation and 4) Strategy Testing. Through incorporation of SDP and SPMP, a novel methodology is offered in this study, which describes how to model, test and simulate dynamic SMs in the vicious cycle of SP practices. Based on the SDP and SPMP, this research is conducted in five consecutive phases to develop dynamic SM model. These are; 1) Development of the research design, 2) Development of the conceptual model, 3) Development of the computerized model, 4) Validation of the computerized model, and 5) Simulation utilizing a real case. Table 1 gives an overview on the research phases along with the steps of SDP and SPMP.

Table 1: Overview of the Research Phases

Research Phase	SDP	SPMP	Chapter	Theoretical Basis
Phase 1: Development of the Research Design	-	-	Chapter 2- 4	
Phase 2: Development of the Conceptual Model	Conceptualization	Strategic Positioning Strategy Formulation	Chapter 5	[53], [2], [4], [4]
Phase 3: Development of the Computerized Model	Formulation	Strategy Implementation	Chapter 6	[76], [50], [77], [78], [61]
Phase 4: Validation of the Computerized Model	Testing	Strategy Implementation	Chapter 7	[4], [4]
Phase 5: Simulation Utilizing a Real Case	Simulation	Strategy Testing	Chapter 8	[79], [80]

1.5. DISPOSITION

As introduced in Table 1, Chapter 2 overviews theoretical background of this research. The chapter begins with a literature review on the concept of strategy, typologies of strategy and different methodologies offered for SP and strategic management. The chapter continues with the definition and methods of PM, and their applications in the construction industry. In Chapter 2, the original concept of BSC and SM, are also explained in detail, as they constitute the underlying methods of this research. The remaining sections of Chapter 2 gives a review on the concept of cognitive and causal mapping which have roots on SD method. Then, the concept of SD is briefly explained by describing the methodology offered by [4]. In the final section, the concept of Resource-Based View (RBV) and dynamic capabilities are given as they are one of the underlying theories of resource accumulations and disposals inherit in the SD models.

Chapter 3 explains the first phase of this research, which is about identification of the research objectives and development of the research design. The chapter starts with the discussion of limitations of current SP and PM methods reported in current literature. These limitations were classified as conceptualization, quantification and implementation problems of current methods. Research objectives were defined in a way to overcome the major gaps reported in the available literature on SP and PM. After the general outline of the research objectives are given, the Research Design is introduced, which was developed based on the structure offered by [4] in the context SD.

Chapter 4 continues with explaining research methodology in detail. It starts with the description of SPMP, which serves as a basis for the design of this research. The chapter continues with the description of research methodology in detail by providing a systematic process about how to develop a dynamic SM model. To computerize such a model, a software tool was facilitated which enables to develop and simulate complex SD-models in a user-friendly environment. In this regard, this chapter also introduces the SD tool, named Stella Architecture, which was used when developing Computerized Model in the forthcoming phases of the research. Finally, this chapter also introduces one of the biggest Turkish construction company, which was collaborated throughout the research to develop the model by using the available knowledge and experience of the company experts. Experts selected from the Company were participated in the model development, validation and testing phases through some set of structured Group Model Building (GMB) sessions. Thus, the final section of this chapter is devoted to the explanation of these sessions.

The Company, which was collaborated in this research, is one of the biggest Turkish construction companies doing business both in national and international markets. As explained in Chapter 4 in detail, the Company is being consistently ranked in the top construction firms in Engineering News-Record (ENR) 250 [81]. The Company furnishes services as the main contractor and investor in more than 15 countries throughout the world. It mainly operates in construction, real estate development, energy, heavy industries and health sectors. By employing more than 50.000 employees, the Company is one of the flag carrier Turkish contractor companies doing contracting business throughout the world.

The collaboration comprised of four steps, serving different purposes. First, an unstructured meeting was held with the Company CEO to capture initial requirements from such a dynamic SM model. Second, mental models and group decisions of the Company Experts were used to develop conceptual and computerized model components of this dynamic SM model. Third, some C-level executives of the Company participated in the Scenario Testing session to simulate the final model under diverse scenarios. Finally, a Strategic Options Testing session was conducted with the Company CEO to test the model under different strategic decisions and its associated outcomes.

To achieve these four purposes; a structured methodology was undertaken with the contribution of Company Experts. The methodology was based on Group Model Building for knowledge elicitation and utilization of groups having different industrial knowledge and educational backgrounds. In total, eight separate sessions were conducted with twenty-three company experts. First four sessions were held to develop the conceptual model as well as fifth session to develop the computerized model of the research, whose findings are explained in Chapter 5 and 6, respectively. After the development of the model, a separate session was conducted to perform some validation tests in order to ensure behavioral and structural validity of the model. The last two sessions were about simulations of the models with the C-level executives of the Company to understand the model behavior under diverse future scenarios and strategic options. These tests were referred as Simulation Testing and Strategic Options Testing, which constituted the third and fourth steps of such a collaboration.

Chapter 5 explains the second phase of the research that is about development of the Conceptual Model. It introduces a novel BSC and Strategy Map Structure (SMS) for construction companies doing business abroad. Based on the Conceptual Model developed in Chapter 5, Chapter 6 explains the third phase of the research that is about development of the Computerized Model. This chapter explains some model assumptions and boundary conditions, which were needed to develop such a Computerized Model. The remaining section of the chapter explains the development process of the Computerized Model step-by-step by also describing the components (i.e. stocks, flows) of such SD models. In the final section, some screenshots from Stella Architecture were given to demonstrate the SFD of the Computerized Model.

Chapter 7 describes the fourth phase of the research that is about verification and validation of the Computerized Model. The chapter starts with giving a brief theoretical background on validation of SD models. Then, the remaining section explains the model validation methodology of this research, which was defined based on the theoretical background given in the previous section. The final section of this chapter explains findings of the verification and validation tests, which were conducted to ensure behavioral and structural validity of the Computerized Model.

Chapter 8 explains the final phase, fifth phase, which is about simulation utilizing a real case from the Company. This phase was conducted in two steps; first, a Scenario Testing was conducted by using the three scenarios developed in the previous steps of the research. Then, a secondary test was conducted to understand the usage of the Computerized Model when testing different strategic options about future direction of the Company. In this regard, the Strategic Options Testing was oriented towards the simulation of model behavior under different strategies tested by the Company CEO.

Finally, Chapter 9 gives an overview of the research along with the findings of the research, its expected benefits, limitations and some recommendations for further researchers.

CHAPTER 2

THEORETICAL BACKGROUND

This chapter overviews the theoretical background of this research. First, a brief review on strategy and strategic management is given. Second, the concept of the PM is reviewed with also announcing two of the most widely utilized PM methods, the BSC and SM developed by Kaplan and Norton. In the following sections of the chapter, the SP and PM practices of the construction industry are reviewed with also giving some implications for the research objectives. In the final section, an overview is given on the theory of the Systems Thinking, SD, RBV and Dynamic Capabilities.

2.1 STRATEGY AND STRATEGIC MANAGEMENT

The term of strategy has military origins [82], whose roots come from General Tzu's classic Chinese writings, mostly from his famous work, the Art of War [83]. Over the years, researchers have interpreted the wisdom and teachings of Tzu and applied it to a variety of fields including twentieth century business strategy ([84], [85]). After 1950's, strategy has come a subject of study in business environments and mostly seen as a task of the general manager. After 1960s, it has taken form in the business policy courses given at universities such as Harvard University. In the 1970s, the term strategy has studied in the books mostly on corporate planning, in the form of exploring opportunities or threats for corporations. After 1970s, academics have developed a growing stream of research addressing the implications of different strategies for the financial performance of organizations. They have mostly focused on the content of strategic options such as innovation, diversification and internationalization. In 1980s, Michael Porter defined strategy as a competitive advantage term, which has further inspired other scholars to elaborate strategy in economics [5]. In different body of research conducted by Henry Minztberg and Andrew Pettigrew, the term "strategy" has elaborated in the field of sociology and psychology ([9], [86]). In 1987, Minztberg defined strategy as "a plan, ploy, pattern, perspective, or position based on the managerial intentions of the organizations" by proposing professionals to have a holistic view for strategy [86]. In 1990s, another stream of research has come to scene, the RBV proposed by Barney [77]. While the development of concept of "strategy" has examined, [53] concluded that "the twenty-first century has seen the emergence and growing acceptance of new streams of research that offer still more promising means of coping with organizational reality" [53].

There is no universally accepted definition of strategy [83] as strategy fulfills different managerial objectives in organizations ([6], [7]). Prominent thinkers in literature have suggested diverse range of definitions, but the way they have elaborated strategy can be clustered in different perspectives. As classified by [83], there exists studies that describe the evolution of the concept of strategy over time [87], studies that attempt to define a single concept, generally a broad definition ([8], [88], [89]) and studies that propose several different ways of strategy perception [86]. They can also be classified in the way they utilized the term strategy; such as strategy and structure [8] long-range planning [11], [87], strategy as patterns ([9], [90]), strategy as practice [91], strategy as decision making ([92], [93]), at a competitive level ([94], [5]), or a corporate level [95], [96].

In one of the earliest approach, [8] conceded that strategy is about actions taken by the company that lead organizational change based on the changes in the organization's environment. For [6], the definition of [8] implies that "strategy has to do with matching an organization to the environment in which it operates". [11] defined strategy as organization's preferences on products and markets which is more concerned with what to produce and to which markets the products will be sold. [97] defined the strategy as a pattern of decisions focusing on firm resources and competence to achieve advantage based on a unique posture, derived from internal strengths and weaknesses as well as external opportunities and threats. According to [98], strategy as a term is concerned with the scope of an organization such as degree of diversification and geographic expansion. [99] defined strategy as a pattern or a plan that facilitates organizational objectives, policies and action sequences into a cohesive whole.

As one of the most influential researcher in the course of strategy, [9] elaborates strategy as "a plan, ploy, pattern, perspective, or position based on the managerial intentions of the organizations by proposing professionals to have an holistic view for strategy. He added; a strategy may act as diverse tools such as a support to decision making, as a vehicle for coordination or as a target. [100] defined strategy as an area of management, whose concern is about the general direction and long term vision of organizations rather than short term tactics or day-to-day operations. Similar to the definition of [100], [101] defined strategy as long-range plans, methods or approaches of companies to reach their goals in competitive environments. A leaner definition is made by [28] as strategy is the course of action taken to achieve organizational purpose.

Porter first defined the strategy in 1980 as a competitive advantage term and described it as a way to achieve competitive advantage [5]. According to [6], "strategy" defined by Porter also pointed out the impact of core competencies and competitive factors on strategy formulation. A more comprehensive and more practical definition is also proposed by [53]. In their book, they defined strategy as ''the direction and scope of an organization over the long term, which achieves advantage for the organization through its configuration of resources within a changing environment, to meet the needs of markets and to fulfill stakeholder expectations". In line with this definition, [53] claimed strategic decisions are about;

a) The long-term direction of the organizations,
b) The overall scope of the activities performed by organizations,
c) Having a purpose of gaining competitive advantage,
d) Undertaking a "change" in the business environment,
e) Developing core competencies and resources, and finally

f) Meeting with the values and expectations of stakeholders [53].

Various business strategy typologies have also introduced in literature in order to classify and formulate strategies as generic terms. One of the earliest effort was made by [102] who developed a typology consisting of defender, prospector, analyzer, and reactor. In 1979, [103] identified four major types of strategies: multiplication (expansion of present products), monopolization (protection of present markets), specialization (in products or services), and liquidation. One of the most widely used typology in today's literature was introduced by Porter in 1980 [5]. [5] introduced his generic strategies as; "cost leadership", "differentiation", and "focus" by claiming that organizations can outdistance their competition by concentrating on these generic strategies ([101], [100]).

Cost leadership is about focusing on cost reduction in the products and services and offering low-cost products compared to competitors. A premise on "cost leadership" strategy necessitates a vigorous pursuit of cost reductions, tight overhead and cost control activities, and cost minimization of administrative functions [100]. Differentiation strategy is about offering the intended customer a special, different or unique value by either offering prior quality, performance or service. It can also be described as "over competing with rivals" through differentiating offered products and services, adding extra value and quality, creating image or brand name, being top at the responsiveness to the client or having prior technological competency [104]. Focus is about targeting on a selected segment of the market in terms of location, product, customer or sector while applying either cost-leadership or differentiation. The idea is that, a firm can respond to a narrow market more effectively than competitors who target a broader market [100].

The generic strategies of Porter are generally accepted as the simplest and widely used classification of strategies [101]. According to [104], all three types of Porter's generic strategies are existed in various construction companies. For instance; procurement strategies of construction companies are generally designed to achieve minimum cost [104], however which are also criticized due to lack of consideration given to the whole life value of the procured goods from the client's perspective ([105], [106]). Another example is about focus strategies. Some examples are; willingness of construction companies to focus on partnering projects, operating with specific type of contracts (i.e. design/build, build/operate/design or private finance initiative projects) [104], sustaining relations with specific client groups (i.e. high tech manufactures or retail stores), doing business in certain geographic markets, carrying out specific business streams or segment of the product line (cast-in-place concrete structures, etc.) [100]. Although authors such as [104] and [100] has found the generic strategic strategies of Porter useful in the construction industry, some other ([107], [108]) has argued Porter's generic strategies as being either "too narrow" or only as a "first step" in understanding of strategic perspectives of construction companies. Indeed, according to [107], these strategies mainly focus on strategic positioning and neglects "demand factors" in the strategy formulation.

Henry Mintzberg, a leading author on strategic management [109] has also focused on the manner in which the strategies are developed. In his works ([49], [86], [9]), he described strategy as a pattern in a stream of decisions, those may occur deliberately or by default ([110], [5], [109]) based on which he differentiated strategies as “deliberate strategies” and “emergent strategies”. Deliberate strategies are the planned and executed strategies by the management, which are explicitly formulated and implemented through decisions intended to achieve specified objectives. Oppose to the deliberate strategies; “emergent strategies” occur because of internal or external pressures or occur by default so that they are implicit in the autonomous decisions of individual managers. Based on the extent of managerial input, authors have further classified strategies into eight types; "planned," "entrepreneurial," "ideological," "umbrella," "process," "unconnected," "consensus," and "imposed." [49] added, in organizations there always exists more than one of these strategies. Although the type of the strategy influences the context of SP, the framework of strategic management process remains same from type to type, which is defined as a continuous cycle of analysis- choice- implementation [104].

In addition, in their book, [111] proposed 10 schools of strategic thought that can emerge in organizations. These 10 categories are given in Table 2, as was also summarized in [112].

Table 2: Ten Schools of Strategic Thought

1. **Design School:** It offers a model of strategy making that seeks to attain a fit among internal capabilities and external possibilities. It is one of the most influential school of thought and home of the SWOT.
2. **Planning School:** It forms through a formal procedure, training, or analysis. It produces each component part as specified, assemble them according to the blueprint, and strategy will result.
3. **Positioning School:** It proposes that only a few key strategies (positions in the economic marketplace) are desirable. Typologies offered by Michael Porter can be categorized in this school.
4. **Entrepreneurial School:** It proposes that strategy formation results from the insights of a single leader, and stresses intuition, judgement, wisdom, experience, and insight. The “vision” of the managers supplies the guiding principles of the strategy.
5. **Cognitive School**: It suggests that strategy formation is a cognitive process that takes place in the mind of the strategist. Strategies emerge as the strategist filters the maps, concepts, and schemas shaping their thinking.
6. **Learning School**: It proposes that strategies emerge as individuals or groups come to learn about a situation as well as capability of their organizations about how to deal with this situation.
7. **Power School:** It proposes that strategy formation as an overt process of influence, emphasizing the use of power and politics to negotiate strategies favorable to particular interests.
8. **Cultural School**: It suggests that social interaction among diverse organizational members on the beliefs and understandings, lead to the development of strategy.
9. **Environmental School**: It proposes that, the environment is the central actor in the strategy making process.

10. **Configuration School**: It stresses that strategies arise from periods when an organization adopts a structure to match to a particular context that give rise to certain behaviors.

In addition to the strategy typologies, various authors have focused on how to plan and implement the formulated strategies. In this field, SP was born as a process to define a road map for organizations, that is the organizations intend to follow [10]. The development of this “road map” starts with the assessment of organization’s environment; that has generally referred as “assessment of the competitive forces”. Second phase includes evaluating the organizations internally to identify key skills and resources, which can be generally accepted as “core competencies”. The following phases are defined as; linking the key skills and resources with the specific opportunities, defining specific corporate objectives and finally developing organizational knowledge assets (i.e. policies, plans, programs and tasks) in order to achieve the defined objectives successfully [100].

Similar to the development process of this “road map”, [11] defined six major tasks that comprise the SP process (1) goal formulation, (2) environmental analysis, (3) strategy formulation, (4) strategy evaluation, (5) strategy implementation, and (6) strategic control. Goal formulation is about setting long-term vision for the organization, following with the environmental analysis to explore the probable environmental factors influencing the way to achieve the long-term vision. Strategy formulation and evaluation are about defining the strategies with the consideration of long-term vision and probable environmental factors. Strategy implementation and control are about taking action and continuous control on formulated and implemented strategies.

Strategic management is a term firstly defined by Igor Ansoff [11] to take SP a step beyond [100]. It is defined as a set of management practices that incorporate the day-to-day operations of organizations to the long-term planning horizons. In other words, it is an enabler with which all “members of a dynamic organization move as one in response to plans made, opportunities, and threats” [113]. [53] described strategic management as the understanding the strategic position and strategic capability of an organization, defining strategic choices for the future and lastly managing strategy in action. The strategic position is about the impact of the external environment on strategy while strategic capability is concerned with the organization’s own capabilities such as resources and competences. The second step, defining strategic choice, is about the development of the basis for future strategies at both the business unit and corporate levels and the options for developing strategy in terms of both the directions and methods of development. The subsequent step, implementing strategies (strategy in action), is undertaken to ensure the defined and implemented strategies are working well in practice.

In addition to the variety of definitions and processes made for strategic management, various theories and intellectual routes have also emerged about how to elaborate strategic management. [83] classified these theories as; 1) Long Range Planning 2) Structure Conduct Performance, 3) Strategic Conflict, 4) Resource Based View, 5) Core Competence, 6) Knowledge Based View, and 7) Dynamic Capabilities. The summary of traditional intellectual routes to strategic analysis as summarized by [83] is given in Appendix 1.

To date, a number of researchers have also studied the concept of strategic management and their applications in the construction industry (i.e. [114], [115], [101], [116], [117], [118], [100], [119], [104], [120]). Indeed, some authors have explored strategic management practices in the specific construction markets. For example, [121], [122] and [123] analyzed the concept of strategy in U.K construction industry, [124] in Chinese, while [125] and [6] in Turkish. As reported in [120], [121] focused on corporate-level strategies for UK-based construction firms, but did not take into account the macro perspectives faced by the industry. [122] focused on business strategies of consultancy firms in the construction industry, but did not draw any strategies for contracting. [123] evaluated the evolution of strategic management approaches in the industry; however did not provide any current strategies entitled. [125] explored international competitiveness of Turkish construction firms by utilizing Porter's diamond framework, however did not carry out any strategic evaluation for the domestic market.

[101] surveyed strategic attitudes of thirteen large construction companies from four countries; Japan, United States, United Kingdom, and Finland. Based on his findings, [101] analyzed a construction company and its business environment from SP perspective. [116] conducted a 3-year-study to explore the key strategic components of the civil engineering industry with conducting content analysis with 574 researches. [120] conducted a survey with administering 52 Turkish construction companies to explore the current situation of the industry in field of strategic management and to analyze the strengths and weaknesses of SP practices of these companies.

[6] analyzed objectives, core competencies, sources of competitive advantage, and strategies of companies operating in Turkish construction industry by using some statistical techniques. [118] defined the strategic groups existed within the Turkish construction industry by a theoretical framework and alternative statistical cluster analysis techniques. Author also classified triggers of competitive advantage of construction companies into two groups; price and non-price factors, which were further elaborated in detail based on the Porter's generic strategies [5].

[100] explored the relevance of "business strategy" context in the construction industry through discussing the technology use and its potential impact on competitive strategy. [109] developed an analytical framework about the relation of strategic management to the design segment of the architecture, engineering and construction (AEC) firms. [124] developed an integrated framework about corporate strategy and critical issues of Chinese contraction industry and measured their dynamics.

2.2. PERFORMANCE MANAGEMENT

Performance management as an approach, firstly undertaken by a firm named DuPont, in the 1920's by measuring the financial performance through the measure of "return on investment" [12]. By 1925, many other financial performance methods and techniques were developed (i.e. [13], [15]) in which "discounted cash flow", "residual income", "economic value added" and "cash flow return on investment" were widely utilized as financial measures [12].

Despite the widely use of financial measures to assess the organizational performance, the dissatisfaction with these measures have started by 1950s due to their some shortcomings (i.e. [126], [14], [127], [46], [31]). First, financial information, in their nature, reflect lagging factors describing the outcome of managerial actions or decision [12]. As lagging factors, these financial measures report only the results and decisions made in the past, thus are of little use in improving current and future performance ([15], [47], [27]). However, there is a need for more current, up-to-date, and mostly nonfinancial information to make better decisions and take actions. Second, relying on solely the financial measures result in inability to measure the leading factors inherit in internal processes of organizations such as innovation capability or regulatory compliance capability. Kaplan and Norton have also discussed some limitations of measurement methods those based on solely financial indicators. In their early and superior publication [1], they claimed that traditional financial accounting measures were successful in the industrial era, however; in today's world, they are insufficient to analyze the skills and competencies of companies, indeed they might give misleading signals about continuous improvement and innovation demands of today's competitive environment.

Since the early 1990s, various efforts have been made on the development of methods those expected to measure organizational performance effectively [25]. One of the early studies was conducted by [127] who discussed the pitfalls of financial performance- based measurement methods, by also suggesting the inclusion of nonfinancial indicators such as market share, innovation, and customer satisfaction. By year 1992, Kaplan and Norton introduced BSC method in HBR as a novel measurement technique [1]. The method, consisting four measurement perspectives has grown its popularity year by year. By year 1994, [128] pointed out some shortcomings of existing data measures and highlighted the necessity of incorporating process measures. [129] emphasized some other measures which are needed to assess productivity, competence and resource-allocation in order to effectively measure business management activities. In year 1998, [130] discussed that beyond the quantitative business ratios (such as financial measures), measurement of qualitative competency also needed for effective management. Detailed critiques on measurement of methods, which use only financial measures, can be found in [25].

Both the theoretical and practical evolution of PM leads the scholars to describe the science of PM in different ways. In construction industry, one of the most up-to-date definition for the term of performance was made by [131]. Authors defined it as the achievement of both efficiency and effectiveness of qualitative and quantitative goals, which effect the overall project success. Vast amount of studies have also reported in current literature on performance systems, measurement frameworks and methodologies. Some of these authors have conducted studies to understand the PM activities of organizations (i.e. [12], [132], [133], [134], [135], [136]). For example, [12] reviewed the major PM frameworks and their application in UK construction firms. [134] defined performance measures based on world-class manufacturing measures such as quality, time, process and flexibility. [135] developed a performance measurement questionnaire to explore the areas of improvement. [136] applied nonfinancial measures in service industry and proposed to classify measures as “determinants” and “results”.

Numerous other researches have focused on developing novel PM methods (i.e. [137], [138], [135], [139], [1]). For example, [137] developed a Performance Matrix in which performance measures are classified as cost and no cost measures. [138] developed a Performance Pyramid in which relations among performance measures are depicted. The pyramid consists measures in hierarchical order such as; operations related with quality, delivery, process time, cost, customer satisfaction, flexibility, productivity, market measures and financial measures.) “Tableau de board” developed by [139], is one of the widely utilized methods in PM literature, which also has similarities with BSC. Among these methods, the most widely accepted and utilized one is the BSC developed by Kaplan and Norton. It is described “as one of the most influential business ideas of the past 75 years by the HBR and has estimated to be used by 40% of the Fortune 1000 companies at the end of 2001 [23]. As the underlying methodology of this research is based on the BSC of Kaplan and Norton, a separate section is devoted to describe it.

Some other PM methods has also developed by adopting quality management models such as the European Foundation for Quality Management (EFQM) Excellence Model in Europe, The Malcolm Baldrige National Quality Award (MBNQA) in the United States, and the Deming Prize in Japan [12]. Although these models were originally developed as business excellence models, they have further used in the context of PM [12]. However, these models has also criticized due to two major limitations. First, they are limited in representing performance criteria of organizations and could not cover necessary measures to assess performance. Second, they either could not incorporate relations among criteria or solely provide simple solutions remaining complexity problems unsolved.

Nevertheless, since the mid-1990s, various authors have also conducted a considerable amount of research on PM in construction industry ([140], [25]). In these studies, construction projects are archetypally appraised in terms of cost, time and quality ([141], [47], [12]) and performance measures are generally relied on efficiency, return on capital and profitability [142]. For example, as one of the earliest efforts, [17] defined cost, schedule, value and effectiveness to measure construction performance. These studies has provided a sound basis for measuring performance of construction projects as well as delivered a collective perception about project success. However, these PM methods have also criticized, as they are either insufficient in aggregation of diverse projects [141] or narrow, reactive and mostly based on financial measures in organizational level (Love and Holt 2000). [142] argued longer-term and broader focus are needed in PM approaches in order to align PM with organizational strategies, business processes and stakeholder requirements.

After the publication of “Rethinking Construction” by [106], benchmarking systems has also get attention as an alternative method for PM in the construction industry. The report of Egan is known as the first benchmarking initiative, called “Key Performance Indicators”, which was launched in the UK and is currently lead by the Construction

Excellence Organization. After the Egan's report [106], many other internet-based benchmarking platforms have developed from which the most four well-known platforms are carried out in Brazil, Chile, United Kingdom and United States [143]. Some of them are the Construction Industry Institute (CII) in the United States [144], the Department of Environment, Transport, and the Regions (DETR) [145], the Department of Trade and Industry (DTI) in the U.K. [63], and the Corporation for Technical Development in Chile [143]. For example, [144] defined measures such as cost, schedule, safety, change and rework to measure construction performance. The CII [144] has also conducted considerable studies on identification of norms of project performance, development of a common set of metrics, implementation of a benchmarking database as well as development of a web-based evaluation system ([146], [147]).

An excellence model proposed by EFQM has particularly utilized as part of total quality management activities [25]. [145] again launched in UK, proposed a KPI program that includes measures of time, cost, quality, client satisfaction, change orders, business performance and health and safety. Another UK-based platform DTI utilized a PM framework consisting of KPIs associated with customer, people and environment [63]. According to [12], the Excellence Model of EFQM, KPI Program of the DETR [145] and Balanced Scorecard of Kaplan and Norton are the three-most PM frameworks utilized in the UK construction industry.

The reports (i.e. [106], [105]) about benchmarking frameworks in the construction industry, have changed the PM philosophy of the industry to a new era [20] that is tendency of the industry to measure industry performance through these frameworks rather than separate measurement methods. Examples of the use of these frameworks can be found in, UK Construction Best Practice Program (CBPP) [148], Office of National Statistics (ONS) of USA [146], Canada ([149], [150]), the Netherlands [151] Portugal [140], and Brazil [143]. The work of [152] has particularly announced as the very first attempt for implementing benchmarking initiatives in construction industry [43], which now plays a crucial role in supporting third-party benchmarking initiatives.

The benchmarking initiatives have also largely supported by academicians [20], and suggested to be used to compare the performance of individual firms with the industry average. For example, [153] developed financial benchmarks for the Canadian construction industry. [133] explored the use of performance measures for benchmarking in construction industry. He focused on four initiatives; 1) KPIs from the UK [145], 2) National Benchmarking System for the Chilean Construction Industry [154] 3) CII Benchmarking and Metrics form USA [144] and 4) Performance Measurement System for Brazilian Construction Industry (SISIND) [155]. As a further effort, [140] combined KPIs with a frontier method—data envelopment analysis (DEA). Authors utilized a Portuguese benchmarking platform for CI, icBench, to integrate DEA and benchmark scores in order to assess a sample of 20 Portuguese contractors.

In addition to the benchmarking initiatives, some other methods have also used to measure success of construction projects. The performance evaluation hypothesis of these studies are generally based on the extent of deviation of the project attributes from the defined control baselines [131], which made industry practitioners to quantitatively measure cost and time variables of projects. Some examples of these measures are, the S-curve method [156], the Program Evaluation and Review Technique (PERT) [157], the Earned-Value Management System (EVMS) [158], [157], and Stochastic S-curves (SS) [159]. Many other researchers have also focused on cash flow forecasting as a key project performance attributes (i.e. [160], [161]).

Construction industry has also widely applied BSC specifically in designing project management framework ([40], [47]), implementing empirical measurement systems [25], conducting case studies for measuring strategic performance [162], and quantifying firm performance by also exploring performance discrepancies [163]. In this regard, [20] adopted BSC by adding stakeholders and market perspectives to make it more appropriate for construction firms. [47] proposed a conceptual framework for construction performance measures by adding project and supplier perspectives to the original BSC to reflect unique features of the industry. A more complex and comprehensive framework was developed by [40], which is based on BSC and EFQM [40]. [25] designed 12 benchmarking measures under the four perspectives of the BSC by suggesting that BSC can be used as a SP and PM method. Authors pointed out that while BSC can successfully align strategic goals with operations, it has also ability to evaluate the overall performance of organizations. [162] also utilized BSC to design performance measures by conducting a case study with a construction firm. Although previous studies revealed that BSC is suitable for construction industry, it still needs to be improved based on some unique characteristics of the industry ([40], [47], [20]). Nevertheless; according to [47], PM methods in construction projects can be clustered into three main perspectives of the BSC; 1) financial perspective such as cash flow and cost benefit analysis, 2) internal process perspective such as critical path analysis and 3) customer perspective.

With the recognition of importance of structured PM systems and consideration of non-financial measures, various authors have utilized and developed some existing measurement systems and applied them in construction industry [42]. As cited in [20]; these systems cover BSC modified by [47] and [25], EFQM used by [40] and [164], Service Quality Scale and Malcolm Baldrige National Quality Award model, utilized by [165] and Performance Prism used by [166], [167] and [42]. In many of these studies, some well-known methods (i.e. BSC) or benchmarking initiatives have facilitated to design measurement frameworks. However, some of these frameworks are too conceptual to be applied in practice, remaining the PM as a theoretical and holistic problem [168]. Still, they are crucial efforts for the PM, even in project-based nature of the construction industry.

2.3. BALANCED SCORECARD AND STRATEGY MAP

Robert Kaplan and David Norton announced their BSC method in the January-February 1992 issue of HBR [1]. The initial idea was combining financial and non-financial perspectives in a single performance scorecard model, which was firstly named as Balanced Business Scorecard [31]. After a research inside 12 companies, Kaplan and Norton developed a PM framework, which they further named as BSC [1] in their first publication “The Balanced Scorecard- Measures that Drive Performance”.

The original framework included financial performance measures as well as some operational measures those categorized under three perspectives; customer satisfaction, internal business processes, and innovation and learning. The framework also aims to enable translation of strategic objectives of companies into a coherent set of performance measures, which balances financial and nonfinancial measures through some perspectives ([1], [20]).

Since then, researchers have widely accepted the BSC as a proper and effective method to support PM process, indeed acknowledged it as one of the best method to translate the strategy into action. As claimed by [169], although there is no definite empirical evidence to confirm that adopting the BSC truly leads to superior performance, anecdotal evidence shows that the popularity of BSC is growing in a variety of applications. Today, various publications on BSC can be found in current literature, either those examining theoretical foundations of the BSC or those investigating practical applications of it in various countries, industries or markets. Several authors have also conducted in-depth studies or published books on their use and implementation. The books of [169], [19], [170], [171] and [172] are some examples in the field of BSC and its applications.

In addition to the use of BSC in theoretical studies, various companies have utilized it as their main PM method, indeed their PM initiatives have largely started with the evolution of BSC. Thus, it is a remarkable method by not only providing a systematic methodology but also triggering the companies to assess their performance in a structured manner.

Through the years, Kaplan and Norton have also improved the theoretical foundation and applicability of their original BSC ([16], [169], [18], [19]) to exempt their model from serious criticism and promote its current worldwide popularity [20]. In the study published a year after its announcement, [16] recommended to use BSC as not only a measurement exercise but also a management system especially to drive a change process. In 1996 version of the BSC, it is further developed from the 1992 version by incorporating outcome measures and the performance drivers of these outcomes, those also linked together to define cause-and-effect relationships [31]. In their own words, [173] described this feed-forward control system as; "measures of organizational learning and growth effect measures of internal business processes which in turn effect measures of the customer perspective and then financial measures". This version is also expected to transform the BSC framework from a measurement system to a strategic management system.

BSC is a PM method that also guides strategic management by systematically translating organizational strategies into a set of performance measures [173]. It enables organizations to monitor short-term financial results while simultaneously tracking the progress and performance of intangible assets that generate growth for future financial performance [173]. It endeavors to incorporate all the requirements and interest of key stakeholders. The term "balanced" reflects the balance between short and long-term objectives, between lagging and leading indicators as well as between external and internal performance measures [174]. According to [21], BSC can also balance value creation process between short and long term objectives through translating strategies into objectives associated operations, customers, innovation, regulatory and social contexts.

Despite the common view of BSC as a measurement method simply evaluating past performance, [173] proposed that measures on a BSC could also be utilized as a management system that communicates strategy. The BSC is expected to align individuals and the whole organization to the strategy, implement long-term strategic targets, and align initiatives to achieve strategic targets, allocate long and short-term resources, and finally enable feedback and a learning loop about the strategy implementation. As the initiatives create results, according to [21] for each BSC measure, strategic initiatives shall be identified those required to achieve the targets of these measures. In this regard, a properly constructed BSC could tell the story of the strategies via linkages of cause-and-effect relationships between outcome measures and the performance drivers of those outcomes [169].

BSC is also expected to support management team by bringing together various disparate elements of a company's competitive agenda into a single management report. It forces companies to become customer oriented, shorten operational response time, improve process and product quality, reduce new product and process launch times, encourage teamwork and emphasize respect for people [1]. It gives management team a summary of their companies from four different perspectives. It minimizes information overload by limiting the number of measures used and provides to focus on only critical measures. Thus, it is suggested as a worthwhile solution for companies which suffer from having too many measures, or which continuously adds new measures with the suggestion of an employee or a consultant [1].

Based on the overall vision and strategy, the BSC enables decision makers to look at their business from four important perspectives by answering to four basic questions; 1) how do the customers see us, 2) what must we excel at, 3) can we continue to improve and create value, 4) how do we look to shareholders [1]. To answer these questions, Kaplan and Norton defined four perspectives in original BSC framework. These perspectives are originally named as "Financial", "Customer", "Internal Process" and "Innovation and Learning" [1], but the last two are renamed "Internal Business Process" and "Learning and Growth" in [169].

The underlying principle of BSC perspectives is; "learning and growth" enables to develop new technologies and processes which provides to decrease cost and increase effectiveness in the "internal business" perspective, which in return enhances the value provided to the customer so increases customer satisfaction, and will finally reap improved financial results ([169], [20], [12]). Brief explanations of each BSC perspective are given as follows;

1) **Financial Perspective**: Financial performance measures are generally about profitability, growth, operating income and shareholder value. For instance; in a case company studied in [1], the company defined its financial goals simply as; "to survive, to succeed, and to prosper". In line with its goals, the company measured "survival" by cash flow; "success" by quarterly sales growth and

operating income by division, as well as "prosperity" by increased market share by segment and return on equity.

2) **Customer Perspective:** The mission statement of various companies is about being first in delivering value to customers, which makes companies to measure their performance from the view of their customers [1]. The BSC enables companies to translate their mission statement into some specific measures that reflect the concerns of their intended customers [1]. Authors also claimed these concerns are generally about time, quality, performance, and cost.

3) **Internal Business Perspective:** Although customer-based measures are essential to enhance financial measures at the end, they should be translated into measures about what the company must do internally to meet its customers' expectations [1]. Measures of the internal business perspective should stem from the business processes that have considerable effect on critical objectives such as cycle time, quality, employee skills and productivity [1]. These measures are expected to define specifically what processes and competencies the companies must excel at, in order to ensure continued market leadership.

4) **Learning and Growth Perspective*:*** Although the customer and internal business perspectives define the critical measures required for competitive success and leadership; they could not solely represent the overall picture of performance measures due to changes on the targets over time [1]. [1] pointed out that in order to achieve intense global competition, companies should make continual improvements in their existing competencies, processes and products and have the ability to launch entirely new products with having expanded capabilities. Authors added; a company's capability to innovate, improve and learn defines directly its value.

Based on the BSC, Kaplan and Norton have also developed the concept of SM in their study of "Strategy Maps: Converting Intangible Assets into Tangible Outcomes" published in HBR in 2004 [76]. From their own words, authors summarized the underlying theory of SMs as follows,

> "companies build their strategy maps from the top down, starting with their long-term financial goals and then determining the value proposition that will deliver the revenue growth specified in those goals, identifying the processes most critical to creating and delivering that value proposition, and, finally, determining the human, information, and organization capital the processes require" [21].

In this regard, SMs are the visual representation of relations among the key components of organizational strategies [22]. They create the "missing link" between strategy formulation and strategy execution by representing how value is created through cause and effect relationships between diverse strategic objectives [76]. They enable an illustration of organizational strategies, whose purpose is to translate the strategy into operational terms and communicate them to employees about how operational duties of each employee will contribute to the overall strategy of their organizations [175].

In a broader understanding, SMs are "intended to help organizations focus on their strategies in a comprehensive, yet concise and systematic way" [18]. They are simple but powerful tools for depicting and formulating strategy. The original SM assumes a one-way hierarchy within which the financial objectives is plotted in the "outcome area" and the remaining portion of the map is created in a downward flow, showing a cause-effect chain to represent how each dimension helps to execute the dimension above it [176]. Various benefits of use of the SMs are proposed in current literature (i.e. [18], [50], [177], [175]). A brief summary of these benefits are as follows,

- They describe strategies in a single picture, which in turn promotes understanding and makes strategies clear.
- They communicate strategies to employees, which in turn encourages greater engagement and commitment to them.
- They explore and map major internal processes, which drive organizational success and value proposition.
- They align organizational resources and investment in human, technology and capital for most effective and efficient use.
- They define explicit customer value propositions.
- They identify gaps or blind spots in strategies, which in turn enables taking corrective or preventive actions earlier.
- They align human resources, information technology capital and organizational culture to internal processes of the business.
- They link strategic objectives to performance measures by also clarifying cause and effect relations among them.

The improvements periodically made by Kaplan and Norton on their original BSC are summarized in Table 3. The table is developed based on the study of [33], which provides a serious review on both the theoretical and practical applications of BSC.

Table 3: Evolution of BSC and SM Methods

Ref	Year	Scope and Findings
[1]	**1992**	• BSC introduced as a superior performance measurement method that includes both financial and non-financial measures • Identification of the four perspectives: financial; customer; internal business; innovation and learning • Balanced scorecard is forward-looking (long-term performance)
[16]	**1993**	• Balanced scorecard is not only a measurement exercise, it is also a management system to motivate breakthrough improvement • Balanced scorecard has greatest impact when used to drive a change process • Identification that transparency is critical to a successful balanced scorecard

		• Measures on balanced scorecard must be specifically designed to fit firm's mission, strategy, technology, and culture
[173]	**1996**	• Balanced scorecard has evolved from a measurement system to a strategic management system • Identification of four major steps in successful balanced scorecard implementation • Reclassification of "internal business process" and "learning and growth", shifting innovation to internal business processes and adding growth element to employee learning • Measures are linked to each other in a causal relationship, unlike before, linked to strategy and vision
[18], [19]	**2000-2001**	• Translating the strategy to operational terms: building strategy maps • Aligning the organization to create synergies: creating business unit synergy • Making strategy everyone's everyday job: creating strategic awareness, defining personal and team objectives, the balanced paycheck • Making strategy a continual process: planning and budgeting, feedback and learning • Mobilizing change through executive leadership
[76]	**2004**	• Visually map strategy • A visual cause-and-effect explanation of what's working and what's not, in a way that everyone in the company can understand • Helps get the entire organization involved in strategy
[170]	**2006**	• Alignment: a source of economic value • Corporate strategy and structure • Aligning financial and customer strategies • Aligning internal process and learning and growth strategies: integrated strategic themes • Cascading: the process • Aligning boards and investors • Aligning external partners • Managing the alignment process • Total strategic alignment

Various studies have also made to quantify performance measures, which are modeled by using BSC or SM methods. Some authors utilized Analytical Hierarchy Process (AHP) or Analytical Network Process (ANP), or combined them to quantify BSC or SMs. For example, [178] designed a knowledge-based system for strategy planning and utilized AHP for SM representation. [179] applied fuzzy AHP with BSC to evaluate SMs. [180] applied AHP and ANP in BSC implementation. [181] conducted a performance analysis on three banks by employing fuzzy AHP, three MCDM analytical method and BSC. [182] developed a model to assess the performance of the R&D departments. [183] integrated AHP with BSC in supply chain management. [184] utilized AHP and ANP to simplify the BSC implementation. [185] quantified BSC measures by using AHP for a European management consulting firm. [186] used AHP to calculate the relative weight of the performance measures regarding an extended BSC developed for lean enterprises. [187] integrated AHP, delphi method, and BSC to prioritize performance indicators and strategies in a pharmaceutical firm.

[188] integrated fuzzy AHP and BSC to assess performance priority weightings of information technology departments.

[189] developed a method to utilize ANP and multi objective linear programming in SM design. [190] used ANP as a quantitative method for performance measurement. [191] utilized ANP for BSC. [192] utilized BSC based ANP to support firm-level outsourcing decision making. [193] integrated ANP and BSC to multi dimensionally assess organizational performance. [194] applied BSC to measure strategic improvement of a biopharmaceutical firm and utilized ANP to prioritize strategic objectives. [195] developed a sustainability BSC for semiconductor industry and utilized FDM and ANP for analysis purpose. [196] utilized ANP for modelling and design of a SM.

Some others have used fuzzy-based techniques, cognitive mapping or combined them to elaborate SMs as fuzzy cognitive maps. For example, [197] utilized Fuzzy BSC and implemented active scorecard system for strategic business process optimization. [198] generated a dynamic network of interconnected KPIs and quantified the cross impact among KPIs by utilizing fuzzy cognitive maps. [177] proposed fuzzy cognitive SMs for performance management scenarios. [199] proposed a Fuzzy BSC to model corporate strategy. [200] proposed BSC with fuzzy linguistic scale to evaluate government performance. [201] proposed a semantic fuzzy expert system for fuzzy BSC. [202] applied fuzzy multi-criteria decision making model to assess performance of a shipping company. [203] applied fuzzy Decision Making Trial and Evaluation Laboratory (DEMATEL) to model cause and effect relationships of SM. [204] applied fuzzy network BSC for performance evaluation and implementation.

[205] constructed a BSC framework based on knowledge management and the fuzzy AHP for evaluating a software company. [206] proposed a BSC-based fuzzy AHP model for comparison of ERP solutions and vendors for textile companies. [207] proposed a model based on BSC and fuzzy AHP for evaluation and selection of business processes for BPM. [208] proposed a method based on the Fuzzy AHP and BSC for evaluating performance of Third-Party Logistics (TPL) enterprises. [209] used fuzzy AHP and Fuzzy TOPSIS for evaluating steel industry performance based on BSC. The study of [177] is one of the significant attempt about simulation of SMs. Author presented a tool that assists in the creation, monitoring and simulation of strategic maps based on the theory of Fuzzy Cognitive Maps.

Some other authors have incorporated some ad-hoc methods used in PM or excellence models. For example; [210] proposed a SM as improvement paths of enterprises and quantified the maps by using Quality Function Deployment (QFD). [211] utilized DEMATEL as a basis for a SM architecture to model cause and effect relationships in the SM [212] utilized Structural Equation Modelling (SEM) for representation of causal relationship in BSC and SMs. [213] utilized DEMATEL to analyze a strategy map developed for banking institutions. [214] applied case-based reasoning in implementation of balanced scorecard. [215] incorporated hybrid MCDM model, DEMATEL and ANP to BSC for performance evaluation and relationship representation of hot spring hotels. [216] presented a structural evaluation methodology to link KPIs into a SM of a banking institution. The DEMATEL is then employed to determine the causal relationships between the KPIs, to identify the critical central and influential factors, and to establish a visualized SM with logical links to improve banking performance.

As a quantification method, these studies generally used ANP, AHP, fuzzy-based techniques or DEMATEL. Less attempts have also made via QFD, SEM, DEA or Cognitive Mapping.

2.4. COGNITIVE/ CAUSAL MAPPING

Corporate strategic decisions are generally made through a process of individual negotiation that is affected from idiosyncratic views, interpersonal relationships and politics [61]. To handle cognitive biases or politics, methods, which support making better strategic decisions with structured decision-making environment, are needed. This necessity rises the importance of use of some Operational Research (OR) methods in the field of SP and PM [217]. Some of these OR methods are; Concept Mapping, Causal Mapping, Cognitive Mapping and Strategic Options Development and Analysis (SODA) and SD modelling, CLD, Group Decision Support System (GDSS), Multi-User Mode of Group Support, Single-User Computer Supported Modelling Process, GMB, and Manual Group Support.

Cognitive maps are the illustration of mental models which provides “a simple graphical representation of a person’(s) thinking, that locates the person(s) in relation to their informational environments” ([218], [219]). A cognitive map can be regarded as “a concept map that reflects mental processing, which is comprised of collected information and a series of cognitive abstractions by which individuals filter, code, store, refine and recall information about physical phenomena and experiences” [220]. Cognitive mapping is based on the George Kelly’s theory of personal constructs [221]. Three main components of cognitive maps are, 1) identity, 2) categorization and 2) cause and argument [218]. The first, “identity”, is about identification of key actors, events and processes included in a cognitive map, while the second one, “categorization” is about defining interrelationships among them. The final, “cause and argument” is about defining the route of the chains among actors, events and processes. Further efforts have also made in which cognitive mapping is incorporated with fuzzy technique, resulting in producing fuzzy cognitive maps. These maps generally requires; defining important components of a system, identifying relations among these components, and running “what if” scenarios to explore how the system might react under a range of possible changes. Cognitive mapping has also widely incorporated by other techniques such as GDM, GDSS or computerized with tools such as Mental Modeler for quantification or visualization purposes.

“Concept maps are graphical representations of organized knowledge that visually illustrate the relationships between elements within a knowledge domain” [220]. They signify the ideas and concepts are related in some way. As a further effort to concept maps, causal maps clarify the cause-effect chain amongst concepts in a form of nodes and paths [222]. The nodes included in causal maps embody future issues, factors, events or outcomes, whereas paths or arrows designate causalities among them. For illustration of causal maps, a teardrop or pyramid shape is proposed by [222] that structure the desired outcome (goal) at the top, and the strategies, key issues, factors and options at a lower level. Eden and Ackermann are one of the most prominent researchers who develop and implement the theories of concept and causal mapping [223]. Some of their studies about concept, causal and cognitive maps can be found from [224], [225], [226], [227], [223].

The development of causal or cognitive maps help to facilitate individual negotiation through producing alternative views, stifling innovation, reconciling and balancing goals, merging issues, factors or events, validating interrelationships, and building consensus during the strategic decision making [222], [228]. In addition, as a visualization tool, cognitive maps can also reveal cognitive, social and emotional benefits through turning socialization of an individual thinking domain into a collective thinking [229]. They also illustrate mental models and informational environments of individuals into a simple graphical representation giving people's thinking and perception as a causal network of relationships.

SODA is another technique in the context of strategy development methods developed by [227]. It is based on application and development theories of cognition ([230], [221]), problem structuring ([226], [231]), consultancy practice [230] and strategic management [222]. It supports strategic problem solving, strategy development and implementation of programs of action by facilitating group decisions, effective negotiations and managing emotional and political biases [227]. As a GDSS tool, SODA has also utilized with MAGS, SUGS [224] and causal mapping or cognitive mapping ([227], [223]).

In current literature, some OR methods having qualitative nature (i.e. cognitive mapping, SODA), have also combined with each other for quantification purposes. Some examples are; SODA with SD modelling ([225], [232], [233]), CLD with multi-criteria analysis [234], and CLD with SD modelling [71]. In general, for the qualitative modelling purposes, which is generally known as the first stage in modelling, widely utilized methods are; cognitive mapping, SODA, and CLD. All of these methods are also followed up by producing quantitative models through incorporating them with other OR techniques such as multi-criteria analysis and SD modelling.

SD modeling, which was developed by Jay Forrester in the 1950s, is another technique for strategy and policy implementation. It has widely utilized for handling dynamic complexity [67]. SD method is based on, a) defining crucial components of a system, b) setting the causal relations among these components with causal maps, and c) running "what if" or "diverse future states" scenarios to stimulate how the system might react under a range of possible changes or uncertainties.

In OR literature, numerous tools have also developed to handle computerization or quantification of OR methods. For example, Decision Explorer Software developed by Banxia (previously named as COPE/ Graphics COPE) was developed to computerize causal map-based models. Based on the architecture of Decision Explorer Software, [235] developed a computer-based decision support tool, Construction Alternative Futures Explorer (CAFÉ), for scenario development and causal mapping. Commercial tools are also available in literature for causal, concept or cognitive mapping, such as “Banxia- Decision Explorer” for causal mapping, “Mental Modeler” for fuzzy cognitive mapping, “Xmind” for mind mapping, “FC Mappers” for fuzzy cognitive mapping, “Matchware” for cognitive mapping, and “Mindomo” for mind view, Stella Architecture of isee Company and Vensim for SD modelling. As described in Chapter 4, this research was used Stella Architecture, developed by isee Company, for computerization, testing and simulation of SD model developed for international construction companies.

2.5. SYSTEM DYNAMICS

“Growing out of control theory and servomechanisms design”, SD was developed in 1950s by Jay Forrester, a professor from MIT. Forrester introduced the concept of “Systems Thinking” in his book Industrial Dynamics [3]. The foundations of SD is based on the philosophy of “Systems Thinking” ([3], [62]), which is about ability to understand that “everything is connected to everything else’ ([62], [66]) in a dynamic and complex system. Based on the philosophy of “Systems Thinking”, Forrester have developed the concept of SD through his forthcoming books; Principles of System [236], Urban Dynamics [237], and World Dynamics [238].

Another author, John Sterman, has also studied SD in his various articles and books. He introduced the concept of “Dynamic Complexity” [66] based on which he explained the theories of “Systems Thinking” and SD. “Dynamic Complexity” is a term born to reflect real life systems, which are dynamic, complex and interconnected. The attributes of systems with “Dynamic Complexity” are classified by [66] as; 1) constantly changing, 2) tightly coupled, 3) governed by feedback, 4) nonlinear, 5) history-dependent, 6) self-organizing, 7) adaptive, 8) characterized by trade-offs, 9) counterintuitive and 10) policy resistant. Based on [66], brief explanations of these attributes are given in Table 4. [66] also added that, among the attributes of Dynamic Complexity; feedback, time delays, stocks, flows, and nonlinearity have generally found most problematic attributes. To be noted that, the theoretical foundation of SD model developed in this research is based on the attributes of “Dynamic Complexity” proposed by [66].

Table 4: Attributes of Dynamic Complexity

Attribute	Description
1. Constantly Changing	Everything changes over different time scales and these different time scales have probability to interact.
2. Tightly coupled	The system elements inevitably interact with each other and with the natural world.
3. Governed by feedback	Due to tight couplings among elements of a system, elements have feedback on themselves, which cause changes or trigger other elements, giving rise to a new situation, which then influences next state of the elements. Thus, dynamics both arise and trigger the feedbacks.
4. Nonlinear	Nonlinearity arises as multiple factors interact in decision-making. Thus, cause- effect chain in a system, effects are rarely linearly proportional to cause.

5. History-dependent	Stocks and flows (accumulations) and longtime delays often mean doing and undoing have fundamentally different time constants; indeed some of them are irreversible, based on their nature and path dependence.
6. Self-organizing	The dynamics of systems arise spontaneously from their internal structure, emerge spontaneously from the feedbacks among the agents and elements of the system and generate diverse patterns in space and time.
7. Adaptive	The capabilities and decision rules of the agents in complex systems change over time. Evolution leads to selection and proliferation of some agents while others become extinct, which shows their adaptation capability.
8. Characterized by trade-offs	Time delays in feedback channels mean the long-run response of a system to an intervention is often different from its short-run response.
9. Counterintuitive	In complex systems cause and effect are distant in time and space while we tend to look for causes near the events we seek to explain.
10. Policy resistant	The complexity of the systems in which we are embedded overwhelms our ability to understand them. Thus, many seemingly obvious solutions fail or actually worsen the problem.

Although the environment is dynamic, complex and interconnected, people tend to make decisions using mental models that are static, narrow and reductionist [66]. Relying on simple mental models is more problematic when elements or agents in a system get more complex and environment of a system change more rapidly. [66] added that "agents make decisions using routines and heuristics because the complexity of the environment exceeds their ability to optimize even with respect to the limited information available to them".

In this regard, SD is a method for modelling and testing formal mathematical models and computer simulations of complex, nonlinear, and dynamic systems [4]. It has been utilized especially in economics, environmental or social systems where a holistic view is crucial and feedback loops are necessary to capture the relations among diverse variables [3]. It has been also used to understand how organization and policy development affect organizational behavior over time [67]. Furthermore, it can be utilized to create scenarios that are akin to a real life problem [68].

One of the major contributions of SD is allowing the quantification and representation of resource accumulations. It can be facilitated to capture differences in resource accumulation strategies among competing firms as well as develop resource maps by eliciting the resource profiles and investment strategies of these firms through eliciting mental models of top managers about their firms' conceptual representation ([69], [70]).

SD can also be facilitated to develop a structured set of guidelines and procedures to discover dominant logic of a decision-making team [239], elicit mental models, capture the prompts that experts facilitate in decision making, and formulate policies for resource accumulation and allocation [67]. It is known as a practical tool for policy makers who can benefit SD to solve important problems [4]. As summarized by [70], SD has contributed to the field of strategy in four research categories, 1) lab experiments in individual and team decision making, 2) bootstrapping decision rules, 3) variation in resource accumulation and implementation strategies, 4) dynamics of competitive rivalry.

In SD literature, a two-stage method is common ([71], [62], [72], [73], [74], [67], [75]) to convey SD interventions in organizations. The first is qualitative modelling which is about development of CLD of a SD model. Second is the quantitative modeling, which is about transforming CLD into a SFD. In traditional SD models SFD consist four components namely; system, feedback, level and rate.

1. **System:** A system is "a set of elements sharing a particular purpose within a boundary" [240]. Depending on its boundary and nature, a system can be about a corporation, an environment, an economic entity, a country or an inventory system [240]. The system has "emergent properties" those dynamically change with time, and "synergy properties" which develop interactions and relationships amongst elements. Thus, a "closed boundary" for the systems is needed to confine the system scope within a period and within a particular problematic area. This boundary should embrace all internal elements, the interaction of which determines the structure of the system. The analysis and modelling purposes of interaction of system elements is further introduces the concept of feedback [240].

2. **Causality and Feedback:** The causal relationship means one element in a system affects another element, which is generally represented by CLD. CLD is largely utilized to formulate a cognitive model and to hypothesize the dynamic and causal interactions between elements. In addition to the causality, feedback in a system indicates polarity of causal elements those can be positive or negative. Positive relationships means a condition in which a casual element (i.e. element A), results in a positive influence on another element (i.e. element B) where the increase of A value responds to the B value with a positive increase [241]. However, negative relationship denotes "a condition in which a causal element, A, results in a negative influence on B, where the increase of A value responds to the B value with a decrease" [241]. These positive and negative polarity lead to two types of feedback; reinforcing (R) and balancing (B). A widely given example to describe these feedback loops is population growth. Such that, "reinforcing loop" generally exemplified as while increases in population increases the birth number which in turn leads to increase in the overall population. To the contrary, "balancing loop" is exemplified, as when the population increases, the number of deaths will eventually increase leading to decreases in population.

3. **Level and Rate:** Although CLD and feedback loops provide representation of causalities among elements and communicate the dynamic behavior of a system; they could not reflect the sensitivity of these elements to each other, to external variables or to time. "Level" and "rate", are the two variables required for modelling the dynamic behavior of a system and simulating its elements. While "level" is about the state or degree of an element within a specific time internal, "rate" reflects the extent of how the level changes within a period. So

that, what determines the difference between the level and the rate is whether the element contains a time factor. The "level" of an element represents its accumulated rate over a period, which in turn determines the "rate" through averaging the accumulated levels over the total time taken. In SD, the level and rate are formulated utilizing SFD for modeling and simulation purposes. In the context of SFD, "levels" are represented as in the form of "stock" variable; "rates" are in the form of "flow". Thus, the value of a "stock" at time t, is quantified by summing the initial stock value with the value of "flow", that is the difference between output and input during the time t-1 and t.

In current literature, a number of authors have used SD in PM approaches. For example, [71] conducted a case study to develop a BSC for insurance industry, which utilized SD as a modelling method to overcome the existing limitations of original BSC. As proposed in SD literature, authors conducted a two-stage SD modelling process to develop BSC. In the first stage, authors captured the qualitative mental models of decision makers by using CLD, which resulted in a SM. In the context of second stage, authors converted CLD into a quantified simulation model, assigned KPIs and preliminary targets and calibrated the model using key company data. Another study conducted by [243], who developed a dynamic BSC by utilizing SD for Australian Defense Force Academy.

In addition, SD modeling has also been used in the construction industry to explore different aspects and performane measures of the industry. For example, one of the most influencial study about use of SD in the construction industry is made by [242]. Authors used SD to assess forces, which shape level of competitiveness of construction firms. Authors developed a "high-level map of a firm in the construction sector" which was further formulated via SD modelling.

SD has also some similarities with Resource Based View (RBV) in strategy [67] as both of them pinpoints the dynamics of resource accumulation [244]. RBV considers the firm as a bundle of resources [245] while "stocks" and "flows" representing the accumulation and dispersal of resources are central to the dynamics of complex systems [66]. RBV argues that resources (i.e. organizational assets, capabilities, processes, information, and knowledge) enable to conceive of and implement organizational strategies ([246], [5], [77]). In this regard, RBV states, "firms possess resources, a subset of which enables them to achieve competitive advantage, and a subset of those that lead to superior long-term performance" [247]. It contends resources, which are valuable, rare and difficult-to-imitate, can lead to creation of superior performance and competitive advantage ([247], [245]).

In addition, RBV argues that resources and the way they are combined, determines how a firm behaves from another, which in turn provides to gain competitive advantage[1]. Competitive advantage is about how (i.e. premising cost or differentiation

[1] Different from RBV, Market Based View (MBV) perceive that, "firms are considered as fairly homogenous and driving force for market competition is branding and positioning efforts of competing firms" [194]. Based on MBV, the strategy for identifying an alternative market for a firm is generally based on the Porter's five forces model; however neglects the decision of "whether firms have enough resource and capabilities to compete in the marketplace" [194].

strategy) a firm can more successfully compete with other firms ([5], [94], [248], [245]). In this regard, RBV argues that competitive advantage can be maintained through longer times to the extent that “the firm is capable to protect against resource imitation, transfer or substitution” [247]. In this regard, RBV suggests four characteristics of resources and capabilities which affect competitive advantage of the organizations; 1) durability, 2) transparency, 3) transferability and 4) replicability [78]). RBV also proposes that both resources and capabilities must fulfill ‘VRIN’ criteria (Valuable, Rare, Imperfect Imitability and Non-Substitutability) for sustainable competitive advantage and sustained superior performance [77].

Prior to RBV, the traditional resources of firms are mostly described as their tangible stocks such as plant, equipment, cash and other traditional balance sheet items. With the evolution of RBV, the definition of a firm’s resources expanded beyond tangible stocks to less obvious, hardly quantified but crucial stocks such as employee skills, customer satisfaction, loyalty, and other form of intangible human, social and political capital [66]. In this regard, numerous authors have studied types of these both tangible and intangible resources. For example; [77] categorized three types of resources namely; physical, human and organizational capital. [249] applied resource types proposed by [77] however added the concept of “capabilities” in addition to the tangible and intangible resources. [78] classified resources into six categories. The classifications of organizational resources and capabilities in available literature are summarized in Table 5.

Table 5: Classification of Organizational Resources and Capabilities

Author	Resource Class
[77]	1. **Physical capital resources:** Physical technology, plant and equipment, raw materials, geographic location 2. **Human capital resources:** Training, experience, judgement, intelligence, relationships, and insight 3. **Organizational capital resources:** Formal and informal planning, controlling and coordinating systems
[249]	1. **Financial:** Internal funds, external capitals 2. **Physical:** Plants, machines, materials 3. **Technological:** Patents, trademarks, copyrights 4. **Organizational:** Management information systems, control systems 5. **Human:** Managerial talents, organizational culture) 6. **Innovation:** Research and development, new products, processes 7. **Reputational:** Reputation as good employer, social responsibility).
[78]	1. Financial resources, 2. Physical resources 3. Human resources 4. Technological resources 5. Reputation 6. Organizational resources
[244]	1. **Physical resources:** Tangible goods -plant, equipment, natural resources, raw material, half-finished products, discarded products, and unsold supplies 2. **Human resources:** Professional, clerical, administrative, financial, legal, managerial and technical teams.

The literature is also rich in definitions of resources and capabilities in order to clarify differences among them. As proposed by [78], resources are accepted as inputs for the accumulations or disposals of capabilities whereas capabilities are about use of a group of resources, which are needed to perform some task or activity. In order words, “resources are the source of a firm’s capabilities, capabilities are the main source of its competitive advantage” [78]. In line with these definitions, while resources can be exemplified as machines, patents, employees or financial funds, capabilities can embody technology, design, production, service or distribution. Various scholars have focused on definition or methodological aspects of resources (i.e. [250], [251], [252], [253], [254], [255], [77], [244], and [78]) as well as some others on capabilities (i.e. [256], [257], [258]).

Although RBV is one of the theories which could explain why organizational performance differ among organizations ([77], [253], [259], [260] studies on it have left some limitations [70]. First, these studies are very limited in defining critical resources, which account for a firm’s success, especially in complex organizational settings ([70], [261]). Second, studies on RBV are limited in considering “interdependencies and complementarities of a firm’s system of resources”. Third, much of the empirical RBV research has remained unsolved the question of why firms possess different resources and capabilities, how competitive advance arise and evolve over time [70]. In addition, the majority of these studies have configured resources “statically” at a particular point, neglecting resource accumulation process over a time. Thus, these researches could not explain, “how differences in resource profiles and performance originate or why leading firms at one point in time have lost their leadership positions at a later point in time” [70]. Additionally, in this era of dynamic world, firms need to develop new capabilities or competencies for maintaining such competitive advantage, which arise the concept of “dynamic capabilities” [252].

Dynamic capabilities are defined as processes of using resources to integrate, reconfigure, gain, and release further resources. They are about organizational processes or strategic routines by which firms develop new configuration for updating resources as per market requirements or changes in markets [262]. Thus; “while RBV primarily concentrates on types of resources and capabilities for its strategic importance, the dynamic capability concentrates on how these resources and capabilities need to change or update over a period of time to keep their relevance in the changing marketplace” [252], [262].

In this regard, growing researches on SD have undertaken to solve the pitfalls of the theory of RBV in strategy as well as to handle dynamic capability (i.e. [263], [70], [69], [178], [264]). SD method enables to consider both tangible and intangible firm-specific resource stocks, the resource accumulations, and the bounded rationality of decision makers ([70], [244], [258], [265], [260]) through modelling parameters in the form of stocks and flows. Resource accumulations are critical in strategic management literature as both tangible and intangible resources, grow and decline gradually over time [71]. It is also crucial for studies focusing on PM applications, especially those conducted with the use BSC, by eliciting time delays and accumulations in BSC [264]. Thus, stock and flow concept in SD method, provides addressing both time delays and resource and stock accumulations in a structured and rigorous manner inherit in SMs and BSC [71].

CHAPTER 3

RESEARCH OBJECTIVES

This chapter defines the research objectives of this study by explaining the gaps identified in the current literature on SP and PM. These gaps were explored under three headings, 1) conceptualization, 2) quantification and 3) implementation problems. The chapter continues with explanation of the Research Design that was developed based on the major gaps explored in current literature. Based on the Research Design, the final section of this chapter explains the Research Objectives by referring to the gaps.

3.1. RESEARCH GAPS

The original BSC and SM developed by Kaplan and Norton are two of the most influential methods in the course of SP and PM. Although, they constitute the basis of majority of the PM approaches in current literature, they have some drawbacks that limit their theoretical and practical applications. As given in Table 6, in this research, these limitations are classified into three groups, 1) conceptualization problems, 2) quantification problems and 3) implementation problems.

Table 6: Research Gaps

Problems	Gaps
1. Conceptualization Problems	**Gap 1:** Ineffectiveness in consideration of environmental conditions
	Gap 2: Lack of a company-level system
	Gap 3: Ineffectiveness in consideration of construction industry-based and non-financial measures
2. Quantification Problems	**Gap 4:** Difficulties in balancing and aggregating measures
	Gap 5: Difficulties in interpreting bi-directional causalities among measures
3. Implementation Problems	**Gap 6:** Difficulties in understanding the strategic relevancy
	Gap 7: Lack of simulation capabilities
	Gap 8: Lack of handling cognitive biases and subjectivity

3.1.1. Conceptualization Problems

Conceptualization problems of current BSC and other PM methods are examined under three gaps, 1) ineffectiveness in consideration of environmental conditions, 2) lack of a company-level system, and 3) ineffectiveness in consideration of construction industry-based and non-financial measures.

3.1.1.1. Gap 1: Ineffectiveness in Consideration of Environmental Conditions

[266] found that almost 60% of the Project Management Systems (PMS) perform under expectations, which is highly contributed to the inability of these PMS to consider organizational characteristics. Authors claimed the implementation of PMS could not be identical in different companies; as these companies vary in terms of decision-making culture, the environmental uncertainty surrounding the companies, organizational structure, size, strategy, norms and values ([267], [268], [266]).

[269] considered the original BSC as being too general, claiming that it might ignore mission of companies and not fit in organization's culture. [33] claimed it is necessary to link BSC measures with the organizational and environmental factors as well as to explore how this link might affect the performance of organizations. [32] claimed that the BSC might not be the exact tool to manage strategy as it is limited in incorporating organizational and socio-environmental rooting. He noted that, the control model of the BSC is based on a hierarchical top-down model ignoring either environmental or organizational conditions, which makes the approach questionable as a strategic management tool.

During the design of the BSC, organizational and environmental factors influencing the strategic positions of the companies should also be considered. Before implementing the strategies, strategic positions, capabilities or purposes should be clarified. Strategic position is about the macro environment surrounding the organizations such as markets or industries in which the organization operates and competitors of the organizations in these markets or industries. Strategic capability is concerned with the core competencies and resources that an organization can utilize to create value to its customers [53]. Core competencies and resources are the basis of value creation process of the organizations which enable them to achieve competitive advantage and differ themselves from their competitors. The last item, the strategic purpose, is related with the intent of the organizations towards diverse fields such as corporate governance, business ethics, social responsibility, shareholder expectations and organizational culture and purposes [53].

Thus, a comprehensive framework representing the whole value chain of strategic management process is needed. According to [53], this framework should incorporate strategic positions, capabilities and purposes of organizations, and clarify its strategic choices. That framework is also expected to make the projection of how the defined strategic choices will be implemented based on the strategic positions of the organizations. Authors claimed; "in this way, more rational decisions can be made about strategies and the performance can be foresighted proactively" [53].

3.1.1.2. Gap 2: Lack of a Company-Level System

Most of the PM efforts in the construction industry have focused on the measurement of project performances and limited in the evaluations at the corporate level (i.e. [40], [41], [42], [43]). Construction companies generally tend to define bidding or project management strategies at the project level, due to project-based nature of the industry [6]. As part of their bidding strategies, they generally focus on tendering system, client, country or bid evaluation criteria. However, due to lack of a broader business strategies formulated at the business level [6], that limited focus remains other strategic decisions unsolved, such as which project to bid or which bidding strategy to use. The study of [41] represented that approximately 68% of the studies on PM in construction, are focused on the project level. Similar statistics can also be found in [42] and [43]. According to [146], even the CII benchmarking approach [144], which has widely utilized in the industry, does not provide a comprehensive measurement of company-level performance of construction companies.

Thus, measurement systems to evaluate organization's performance or benchmarking tools to compare the organizations performances are lacking [270]. To empower PM in the construction industry, a structured and complete measurement system is needed, that considers both the project and company-level measures ([25], [40], [271]). Although some studies have undertaken which focus on corporate-level performance of construction companies (i.e. [164], [270], [40], [43], [140], [25], [271], [162]), a generic PM system is still lack, which aggregates project and corporate-level measures.

3.1.1.3. Gap 3: Ineffectiveness in Consideration of Industry-Based and Non-Financial Measures

According to [44] and [45], majority of the initiatives about implementing BSC in practice, are failed due to insufficiency of four perspectives of BSC. After three case studies, [46] found that BSC is generic and the perspectives involved in the BSC might be different for different business sectors or environments. [16] proposed that the original BSC should be modified based on the country, business or industry where companies operate. Authors claimed that; their original BSC is not a template that can be generalized to whole businesses or industries; as different markets, product strategies or competitive environments require different BSCs. In literature, some studies can be found those modified the original BSC either adding new perspectives or revising existing ones in original BSC. For example, [48] added "employee" and "competition" perspective as additional perspectives to the original BSC.

There are also other BSC modifications those identified industry-specific perspectives. For example, [47] studied the solicitation of BSC in the construction industry. As the construction projects involve diverse number of stakeholders, authors modified the original BSC by adding two perspectives namely; project and supplier perspectives. [20] added market and stakeholder perspectives to the original BSC by claiming that the revised BSC is more appropriate and applicable in international construction firms. [20] proposed that the revised BSC can reflect the market expansion and value realization to stakeholders, which are of vital importance in internalization. As reported in [12], other examples of additional or modified perspectives on the original BSC can be found in [272], [46] and [273].

In addition, although BSC method considers non-financial indicators, the methodology for defining or assessing non-financial indicators still inherent ambiguity due to their qualitative nature. Soft issues such as leadership, people, and learning need more research [12]. However, these measures, which represent organizational or cultural characteristics, are vital to assess performance of companies and their projects [133].

3.1.2. Quantification Problems

Quantification problems of current BSC and other PM methods are examined under two gaps, 1) difficulties in balancing and aggregating measures 2) difficulties in interpreting bi-directional causalities.

3.1.2.1. Gap 4: Difficulties in Balancing and Aggregating Measures

Various authors (i.e. [34], [35], [36], [53], [29]) have found it difficult to identify the relative importance of and the trade-offs between the BSC perspectives [33]. However, the identification of relative importance among perspectives is crucial especially when targets of different measures or strategies conflict with each other or require similar resources or competencies. For example, a strategy about improving technological capital of a company might require additional administrative budget while one of the financial strategies of the company might be about decreasing the administrative budget of the company. Thus, identifying the relative importance among strategies or the dependencies among performance measures are crucial to overcome any conflicts in setting targets for these measures and properly “balance” BSC perspectives.

To truly balance strategies in BSC, [33] recommended clarifying the causal relationships among BSC perspectives, and assessing the real impact of KPIs on organizational strategic outcomes. He suggested utilizing a holistic view within the concept of contingency “fit” ([274], [275]), in order to explore causalities among many contextual and structural variables included in BSC perspectives. [39] added that; SMs have also criticized as being ineffective in both measure selection and target setting. These maps have also criticized due to their interpretation and communication limitations. [39] argued that, it is difficult to cascade down top-level BSC into lower levels of organizations, or aggregate lower levels to the top-level which limits their use and understanding throughout the organization.

In addition to the balancing problems, limitations in aggregation of measures are also one of the most criticized problems about traditional BSC. In decades where only financial measures were used in PM, they were easily be aggregated over organizational levels or across functions. However, with the recognition of non-financial measures since the 1990s, different types of measures have defined which make aggregation among diverse measures as a complicated task. Some authors have developed quantitative models (i.e. [276], [277]) that structure the performance measures hierarchically, assessed dependency between measures and quantified the overall performance of projects or organizations. For example, AHP combined largely with fuzzy technique (i.e. [276], [277]), ANP (i.e. [278], [279]), and DEMATEL (i.e. [216], [211], [280]) are among these methods.

However, there remains room for improvement about how aggregations or interactions of diverse measures could be reflected to the PM approaches. To do so, [131] suggested two probable ways to solve the aggregation problems. First; possible interactions of measures should be considered when computing the final priorities of measure weights such as additive interdependence methodology proposed by [281]. Second; rather than point judgements, range judgements can be facilitated in which expert judgements are represented as probability distribution functions, as well as in which priority weights are determined by using Monte Carlo simulation.

However, despite the consensus on importance of measure aggregation, its practical application is still limited due to complexity involved in the process. For example, based on the recent applications of uncertainty and chaos theory to management, [282] argued that, measures should not be decomposed into their components. Authors claimed that, numerous factors affect outcome of even a single measure, a slight change in any of these measures have potential to result in major changes in the outcomes of these measures, thus efforts to aggregate measures are pointless. Nevertheless, the necessity for robust PM methods remains, which can address the validity, usability and practicability of aggregation methods.

3.1.2.2. Gap 5: Difficulties in Interpreting Bi-Directional Causalities

[283] proposed that BSC is capable to incorporate outcome measures and the performance drivers of outcomes as well as to link them in the form of cause-effect relationships. However, various authors (i.e. [32], [38], [39], [33]) claimed Kaplan and Norton's BSC provides little empirical work on the causal relationships among BSC perspectives. According to [33], it is crucial to solve any misunderstandings or ambiguities regarding the cause-effect relations among different perspectives in order to achieve the desired outcome of BSCs.

[33] also discussed reasons for the failure of BSC in interpreting bi-directional causalities among perspectives. The first reason is generally attributed to the representation of causalities among perspectives as too simplistic or uncomprehensive. [38] exemplified that, in the work of Kaplan and Norton, there is a relation between customer satisfaction and loyalty, as well as between loyalty and financial results. However, it might be misleading assumption to generalize that "high level of satisfaction will lead to increased customer loyalty and increased customer loyalty is the single most important driver of long-term financial performance". Here, the single and one-way dependency among perspectives is cited as the source of the problem, rather authors claim there could be any other perspectives that would be the major driver for long-term financial performance.

[31] criticized two major assumptions the BSC is built upon; first BSC can successfully represent the cause-effect relations among perspectives, second the BSC is a strategic management system. Based on the concern of [30], [31] argued that any missing link or cause-effect relationship might lead invalid assumptions in a feed-

forward control system, which in turn cause organizations to anticipate faulty performance measures, resulting in dysfunctional organizational behavior and flawed performance.

[39] argued that the strategic linkage model of original BSC which represents causality flowing from “Learning and Growth” to ‘Financial’ cannot be justified in many organizations. [32] also claimed, although cause-effect chains in BSC introduces the concept of dynamic systems thinking, there is a contradiction as “a cause-and-effect relationship is a deterministic phenomenon presupposing stable structures within a system, which is not particularly dynamic.” Nevertheless, original BSC is based on one-way linear and static causal flows; however, feedback loops are needed to reflect non-linear problems of the real life [67].

3.1.3. Implementation Problems

Implementation problems of current methodologies are examined under three sections; 1) difficulties in understanding the strategic relevancy, 2) lack of simulation capabilities, and 3) lack of handling cognitive biases and subjectivity.

3.1.3.1. Gap 6: Difficulties in Understanding the Strategic Relevancy

The literature has comprised of generalized models for assessing and monitoring construction projects. However, these models are largely limited in precise definition of indicators, which will accurately portray the performance measures and changes. In addition, these models generally rely on too many measures which can lead to “reporting and disseminating every piece of information gathered on the job” [132] those having only “supporting” purposes rather than providing information about “significant process” [284]. In addition, utilizing too many measures might result in difficulties for the companies to understand what should be the priority and how the company can be compared with its competitors [285].

[286] also criticized the phenomenon that, few of the measures applied in PM systems provide key information to support decision-making process of managers. Thus, more simplified methods are necessary which can accurately portray the data needed to forecasting the performance measures [132]. [12] also added that, “managers want as easy solutions as possible with minimum alterations of their existing company measurement systems”.

In addition, the classification among performance measures should also be clarified in order to make them more understandable. For example, [133] argued that; clear and precise distinctions should be made for measures utilized for different project tasks or attributes. These measures can be classified as, measures that relate to the construction process, the organizational performance, facility performance or client or end-users needs and requirements.

Numerous other authors (i.e. [12], [22], [16], [287], [288], [289], [126], [45]) condemned that current PM models are highly poor in implementation and handling change management when any changes occur after the implementation. According to

[45], poor implementation of any PM systems can lead to the failure of even the best-designed system. Authors highlighted the need for more robust implementation techniques “that adopt change management as an integral part of the implementation process”.

3.1.3.2. Gap 7- Lack of Simulation Capabilities

Traditional BSC and SMs are highly criticized as being too much of an inward-looking exercise. As discussed in Gap 5, cause-effect chain inherit in SMs depict a one-way, linear hierarchy instead of representing non-linear and two-way linkages, making SMs to ignore the dynamic feedback loops inherit in real life ([290], [291], [31], [67], [50]).

Several other authors (i.e. [292], [293], [294], [295]) have also argued the dynamism and flexibility problem inherit in existing PM models of organizations. Although new measures are added to these models when any new operations are added to the organizations, obsolete measures are rarely deleted which makes these systems overloaded with measures as well as even more complex and hard to handle. Authors concluded that systems having dynamic and flexible characteristics, are needed which can modify themselves when any external or internal changes occur.

Although there is a consensus on implementing dynamic SMs or PM models, many of them still have static nature [295]. However, relying on a static SM means to “assume not only that the organization and its strategy will stay the same, but also that competitors will continue to behave in the same way.” In other words, they are limited in reflecting the evolution of strategy over time [51]. In addition; although they are supposed to have predictive abilities; they are incapable of analyzing past data to predict future states as they do not include possible time lags among performance measures as well as they ignore relationships among future states and conditions ([51], [50]). [133] added that dynamic and flexible systems are needed in order to accommodate strategic changes. Authors argued that these changes are frequent in companies that have “emerging strategies”, thus PM models should be dynamic enough to sustain the strategic relevance.

A number of other authors (i.e. [177], [53]) have debated simulation problems of traditional SMs or PM models. [177] proposed that current tools in strategy and PM literature solely represent performance in the earlier times of operations, rather than providing simulation of performance over a time horizon. [53] argued the tools and models having simulation capabilities can be beneficial for managers in two folds; first for training in strategy making and second for utilizing in actual process of strategy making. Authors added, simulations could be useful to develop and test diverse business scenarios in case external environment is also analyzed in strategy making.

Although SMs are useful in implementing organizational strategies, they could not enable organizations to alter changes, uncertainties and trends that lead to changes in strategies or performance measures [50]. [133] recommended execution of dynamic simulations of benchmarking models and performing what-if analyses by utilizing these dynamic models. As a broader view, [50] suggested that a theory is needed to accommodate uncertainties and fuzziness in SMs and overcome limitations in prediction of future states.

3.1.3.3. Gap 8: Lack of Handling Cognitive Biases and Subjectivity

Another problem of current PM methods is their limitation in supporting decision-making process of managers. Indeed, some authors argued that PM methods have no use if they do not provide any guidance or support to decision-making [45]. Authors added that further studies are needed to overcome the failure of managers to translate measurement data into set of actions by suggesting necessary remedies.

In addition, the studies of [296] and [297] provide evidence of bias and conflict involved when evaluating performances of companies those adopted the BSC. For example, [297] observed significant conflict and tension between top and middle management about the results of BSC in an international manufacturing company. Authors experimented that, managers perceived BSC measures as inaccurate and subjective, elaborated their PM practice in a manner of top-down hierarchy instead of participative communication, and used inappropriate benchmarks as evaluation basis.

In addition to the bias in PM methods, numerous authors have also criticized the subjectivity problems involved when assessing performance measures. According to [173], [169] has not exactly specified how the decision makers should combine, assess and formulate performance measures, in fact they advocate subjective assessment in PM by claiming that subjective assessments are "easier and more defensible to administer and also less susceptible to game playing". However, to formulate a PM problem subjectively, decision makers need to understand context and relations among these measures, which is hard for a human to handle complexity and assess measures analytically [298]. [299] added, as there is no objective and computational procedure available, decision makers should spend time to think about how to handle this complexity and to search for solutions. In the construction industry, [300] claimed that project performance has generally assessed on personal experience without a standard of evaluation procedure, leading to two project managers assessing the same project differently using the same data [131].

In addition to the subjectivity problems, complexity of the process as well as incapability of human mind to solve complex systems, are among other limitations. [301] argued that "the mental constructs and heuristics that managers bring to bear on complex tasks are fundamentally dynamically deficient." Human cognitive capabilities and mental representations about complex tasks are highly discussed in current literature. First, human cognitive capabilities do not include the ability the intuitively solve complex systems those include high-order and non-linear differential equations. This phenomenon results in poor and highly simplified judgements about systems tending to exclude site effects, feedback processes, delays and other elements of dynamic complexity [243].

In addition to the above-mentioned eight gaps, some others also exist both in theoretical and practical applications of PM. First, more research is needed for defining specific measures, mostly relating to the soft issues such as leadership, people, innovation, learning, partnership, and technology management. Other problem is about design of measures applicable to construction. Although various frameworks are proposed for the design of measures, the process for defining measures those specific to construction industry is still scarce. In addition, “the cascading and aggregation of measures vertically between the organizational and project levels has not been adequately researched” [12]. Finally, more research might be undertaken to explain and measure strategy deployment through developing and applying PM methods [12].

3.2. RESEARCH DESIGN

The aim of this research is to develop a dynamic SM model by incorporating scenario analysis and systems thinking to enhance SP and PM practices of international construction companies. To do so; the BSC and SM developed by Kaplan and Norton are taken as basis for strategy formulation, implementation and testing purposes. In addition, the underlying theory of the research is constructed based on the principles of scenario management proposed by [2] and the SD method developed by [4]. These methods are further incorporated with the BSC and SM methods of Kaplan and Norton. Prior to the identification of research objectives, firstly a Research Design is structured, which answers the question of how the current gaps in literature can be overcome.

This research elaborates the term “strategy” similar to [97], who defined the strategy as;

> “the pattern of decisions in a company that determines and reveals its objectives, purposes, or goals, produces the principal policies and plans for achieving those goals, and defines the range of business the company is to pursue, the kind of economic and human organization it is or intends to be, and the nature of the economic and non-economic contribution it intends to make to its shareholders, employees, customers, and communities”.

In line with the definition of [97], the strategy defined in this research has links to strategy “as a pattern in a stream of decisions” from [86] by also supporting three strategic thoughts proposed in [111];

a. **Design School:** Design school proposes a model of strategy making that seeks to attain a fit between internal capabilities and external possibilities. This research aims to develop a model that facilitates internal resources and capabilities as well as external threats and opportunities while making strategic decisions or measuring performance. In this regard, the model is expected to incorporate theories of RBV, dynamic capabilities and scenario analysis to the Design School type of the strategic thoughts of the decision-makers.

b. **Planning School:** Planning School supports producing each component of the overall strategy separately by facilitating formal procedure, training, analysis, assembling these separate components to produce the overall strategy. This research aims to develop a model based on a SMS, which incorporates diverse strategic fields included in BSC. Each perspectives included in BSC refer to interrelated strategic objectives, all which form the overall SMS. The Structure includes diverse strategic fields; such as finance, stakeholder, human capital, technology or business growth, each of which require different procedures, training or analysis to develop, implement and monitor.

c. **Cognitive School**: Cognitive School supports strategy formation in a cognitive process that takes place in the mind of the strategist. In the context of this strategic thought, strategies emerge as the strategist filters the maps, concepts, and schemas shaping their thinking. This research aims to develop a model that facilitates systems thinking in order to support cognitive models of the decision makers in SP through visualizing interdependencies among strategies as well as simulating the strategies over years. Incorporation of the dynamic nature of strategies via systems thinking is also aimed to inform strategic decision as strategies might be formed as a result of actions, which may not necessarily intended [86].

In line with the definition of strategy and types of strategic thoughts premised, a novel Strategic Performance Management Process (SPMP) is developed to implement and use the dynamic SM in a structured manner. As explained in Chapter 4 in detail, the SPMP can be utilized during the whole life cycle of SP and PM. To do so; the definition of strategic management made by [53] is adopted;

> "Strategic management can be summarized as the understanding the strategic position of an organization, making strategic choices for the future and managing strategy in action. The strategic position is concerned with the impact on strategy of the external environment, an organization's strategic capability (resources and competences) and influence of stakeholders. Strategic choices involve understanding the underlying bases for future strategy at both the business unit and corporate levels and the options for developing strategy in terms of both the directions and methods of development. Strategy in action is concerned with ensuring that strategies are working in practice."

The dynamic SM model is expected to overcome the gaps of the current literature and provide an alternative method for traditional SP and PM practices. To do so; a novel "thinking philosophy" is needed about how the strategy is formulated, implemented and executed. Taking the definition of [53] on the strategic management as basis, this "thinking philosophy" is about transforming static nature of traditional PM methods to a dynamic nature. In this regard, the scenario management theory of [2] is found to be convenient, which is taken as basis for dynamic SM model offered in this study.

The scenario management theory developed by [2] is based on three major principles; 1) systems thinking, 2) future- open thinking, and 3) strategic thinking. As depicted in Figure 1, the first, "Systems Thinking" provides organizations to handle increasing complexity, diversity and dynamics in the organizational environment by dealing with interconnections in the system [65]. Second, "Future-Open Thinking" is related with making predictions of future trends and developments by projecting current-state to the future. It is about acceptance of uncertainty in the corporate environment and detection of alternative possible developments. Finally, “Strategic Thinking” is about identification of prerequisites of future success potentials as a basis for development and implementation of visionary strategies. According to [2], a traditional scenario technique should be combination of “Systems Thinking” and “Future-Open Thinking”, while “Strategic Thinking” combined with the “Future-Open Thinking” will lead to “Scenario Planning”. In addition, taking “Systems Thinking” and “Strategic Thinking” as a basis, SD method can be facilitated. Authors concluded that; in order to conduct a comprehensive scenario management process; all of three principles should be combined and facilitated concurrently.

The main principles of scenario management defined by [2] are needed in order to alter current gaps of the SP and PM methods. As explained previously, current BSC methods are limited in reflecting the bi-directional causalities among KPIs. “Systems thinking” is needed in this regard, as it provides decision-makers to elaborate BSC as a system of KPIs in which interdependencies among them are represented in the form of diverse and dynamic interconnected system components. Another limitation of current BSC and SM methods are widely cited as their inability to handle dynamism, which makes them as “static” representations of the strategy. Thus, “Future-Thinking” is needed as it provides decision makers or policy makers to accept the uncertainty involved in the corporate environment so that consider the changes occurred in their strategies. Hence, it is needed to elaborate the BSC or SMs as “system” itself, and incorporate the theory of SD in the practices of SP and PM.

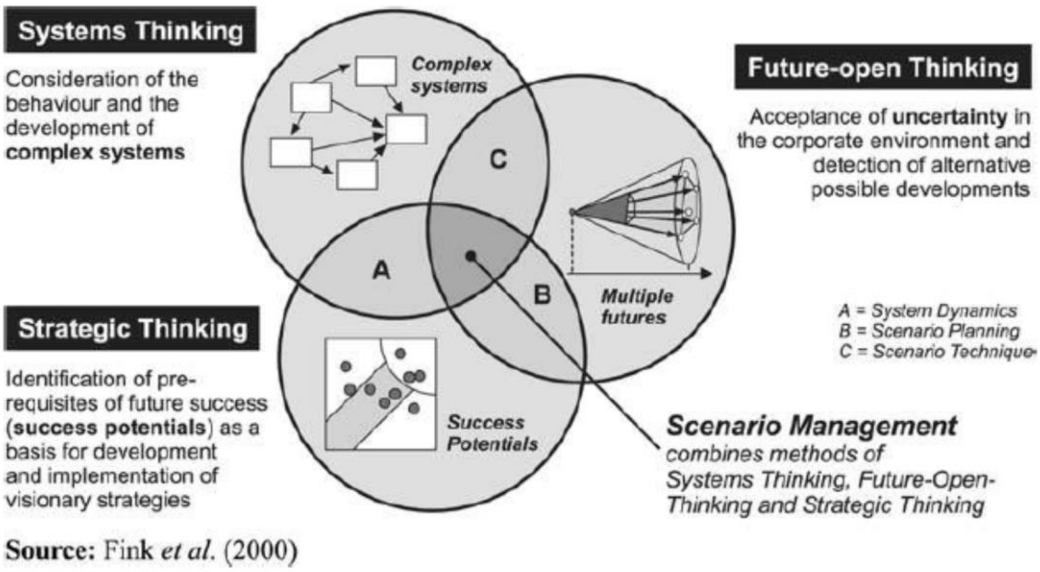


Figure 1: Main principles of scenario management developed by [2]

Based on the scenario management principles of [2], it is aimed to incorporate SD in traditional scenario analysis and PM practices. SD models are usually “formulated as systems of high-order, nonlinear, possibly stochastic differential equations portraying the decision rules of the agents, natural processes, and physical structures relevant to the purpose of the model” [70]. As will be explained in the forthcoming chapters, the methodology offered by [4] is taken as basis when developing the dynamic SD model.

A two-stage approach including qualitative and quantitative modelling is a common approach in SD literature ([71], [62], [72], [73], [74], [67], [75]) to convey SD interventions in organizations. [66] proposed a five-stage process to build these qualitative and quantitative models by SD. First step is the “Problem Articulation” in which the key variables of the system are identified. Second step is about “Formulation of Dynamic Hypothesis”, which consists of endogenous focus, hypothesis generation and mapping with causal loop or stock flow. In this research, these two steps are combined and referred to as “Conceptualization”. Third step of the methodology proposed by [66] “Formulation of the Model”, in which the relationship between cause and effect variables are analyzed. Fourth step is about testing the Model through sensitivity analysis or other techniques to test and validate the model. Final step is about “Policy Design and Evaluation”. In this research, the associated steps are conducted namely; “Formulation”, “Testing” and “Simulation”, the last one “Simulation” representing the “Policy Design and Evaluation” step proposed by [66].

Thus, similar to the methodology utilized by [66], a System Dynamics Process (SDP) is developed in this research, which includes four steps, 1) conceptualization, 2) formulation, 3) testing, and 4) simulation. The detailed explanations of these steps are as follows;

1. **Conceptualization:** Conceptualization step is the first step for the development of the SD model. It is about identification of “system” parameters (BSC measures) as well as development of the system interactions (bi-directional relations among measures in SM). To do so, a CLD is developed to conceptualize the dynamic hypothesis of SM and describe the causal relationships among BSC measures. In this step, GMB sessions are conducted to depict the cognitive models of decision makers and construct the conceptual SM. These sessions also provide to understand the existing levels and boundaries of the organizational resources, capabilities as well as the strategic intent of the Company towards its future state. The model developed after the “Conceptualization” step is named as “Conceptual Model” and referred as so throughout the thesis.

2. **Formulation:** Formulation is the second step for the computerization of the “Conceptual Model” in a software environment. To do so, the CLD is extended and converted into a STD to model in order to test and simulate the SM. STD is developed and computerized via a software tool, named Stella Architecture of isee Company. For the formulation purposes, additional quantitative variables are also included in the system in order to support mathematical formulation. The initial values, such as constants, rates, resources and capabilities, are gathered from Company latest annual report by the researcher or captured from the verbal statements of decision makers in GMB sessions. The model developed after the “Formulation” step is named as “Computerized Model” and referred as so throughout the thesis.

3. **Testing:** Testing is the third step undertaken to verify and validate the “Computerized Model” developed by Stella Architecture. To do so, numerous verification and validation tests are undertaken to ensure both structural and

behavioral validity. Some of these methods are; verification of feedback loops by decision makers, comparison of historical data to simulation output, validation on the model in extreme circumstances, and sensitivity tests on various variables ([302], [66], [240]). In this research, dimensional consistency test, behavior adequacy test, extreme conditions test or structural verification test are among some of the verification and validation tests those undertaken iteratively.

4. **Simulation:** The final step is the "simulation" in which two separate tests are undertaken with the Company to understand the behavior of the Computerized Model in real life practices. First, a Scenario Testing is conducted to elicit dynamic behavior of the model under diverse future scenarios. Second, a "Strategic Options Testing" is undertaken to understand the effect of changes in resources and capabilities to the overall strategic achievement.

In line with the SDP, a Research Design is developed based on the studies of [303], [304] and [305], who were also taken the model of [4] as a basis. As depicted in Figure 2, the Research Design consists three components; 1) problem entity, 2) conceptual model, and 3) computerized model, which are briefly described as follows;

1. **Problem Entity:** The problem entity is the system (real or proposed), idea, situation, policy, or phenomena to be modeled [303]. In this study, a detailed literature review is conducted to understand, capture and report the problem existing in the current SP and PM methods. The definition of the problem entity was given in Table 6 in Chapter 3.1.

2. **Conceptual Model:** "The conceptual model is the mathematical, logical, verbal representation of the problem entity developed for a particular study" [303]. It is developed through analysis and modelling phase. In this study, the Conceptual Model is the SMS utilized to define and visualize strategic objectives of the company and assess their performance. The methodology and findings of the Conceptual Model are explained in Chapter 5.

3. **Computerized Model:** The Computerized Model is the Conceptual Model implemented in a software environment. The Conceptual Model is transformed into the "Computerized Model" through component of "Computer Programming and Implementation". As a further effort, inferences in the problem entity are captured by carrying out "Experimentation" on the Computerized Model [303]. The methodology and findings of the Computerized Model are explained in Chapter 6. In addition, the "Experimentation" is described into two parts; a validation process as described in Chapter 7 and experimentation with a real case as in Chapter 8.

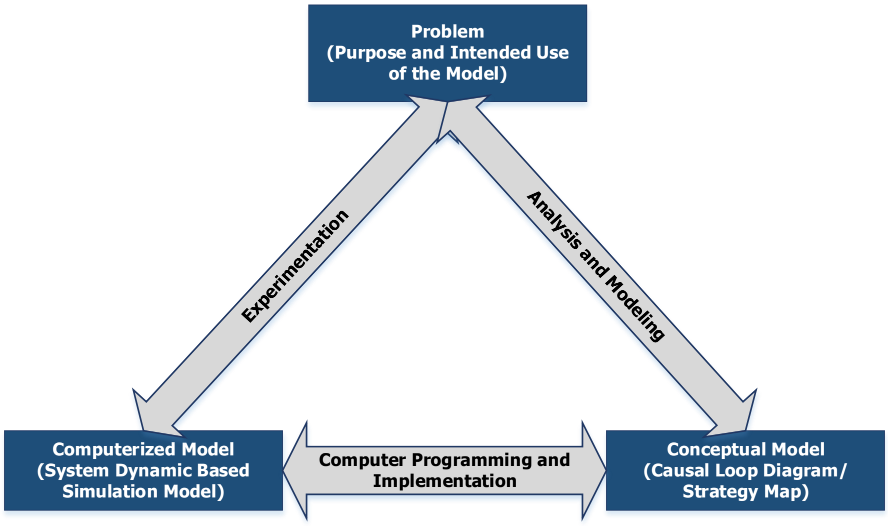


Figure 2: Research Design

3.3. RESEARCH OBJECTIVES

The aim of this research is to develop a dynamic SM model by incorporating scenario analysis and systems thinking to enhance SP and PM practices of international construction companies. This research targets to overcome some limitations of the current literature on SP and PM applications. In line with this target, the objectives of this research are defined as a way to provide means to alter some gaps in current literature as reported in Chapter 3.1. These objectives along with the research gaps are given in Table 7.

The SD method is selected as the basis of the research methodology in order to overcome some gaps mentioned in Chapter 3.2. The methodology of this research is developed in line with the Research Design, depicted in Figure 2. The research objectives are also elaborated in line with the Research Design in order to maintain the overall purpose throughout the research. Both the Conceptual Model and the Computerized Model given in the Research Design are intended to overcome different limitations of the literature.

The final dynamic SM model will be utilized for formulation, assessment, visualization, decision-support and simulation purposes. It is aimed to enable decision makers to consider current and future strategic position of their companies when making strategic choices as well as to test and formulate strategies through diverse simulations. In other words, using the Computerized Model, it is aimed to understand the behavior of a system, and easily test hypotheses about strategic options with simulations. In addition, with the use of the Computerized Model, it is expected that the industry practitioners could make better decisions with the improved understanding of dynamic relationships within a system, and could communicate their mental models in a structured manner. Finally, the model is expected to be useful when implementing strategies in terms of some set of described and communicated KPIs.

Table 7: Research Objectives along with the Research Gaps

	Research Gaps	Research Objectives
1. Conceptualization Problems	**Gap 1:** Ineffectiveness in consideration of environmental conditions	1. To develop a model that provides to incorporate internal and external environmental conditions of the companies into their SP and PM practices
	Gap 2: Lack of a company-level system	2. To develop a model that conducts company-level PM rather than solely focusing on performances of single projects
	Gap 3: Ineffectiveness in consideration of construction industry-based and non-financial measures	3. To develop a model that reflects industry-based characteristics in PM practices via both financial and non-financial measures
2. Quantification Problems	**Gap 4:** Difficulties in Balancing and Aggregating Measures	4. To develop a model that enables to balance the strategies and automatically aggregate diverse measures
	Gap5: Difficulties in Interpreting Bi-Directional Causalities	5. To develop a model that considers interdependencies among measures included SMs
3. Implementation Problems	**Gap6:** Difficulties in Understanding the Strategic Relevancy	6. To develop a model that helps to understand the strategic relevancy of performance measures to the strategies set previously
	Gap7: Lack of Simulation Capabilities	7. To develop a model that has simulation capabilities to understand dynamic behavior of the strategy and enhance the quality of strategic decisions made
	Gap8: Lack of Handling Cognitive Biases and Subjectivity	8. To develop a model that supports decision making process of experts in SP through handling subjectivity and cognitive biases

3.3.1. Conceptual Model

The Conceptual Model is aimed to be a basis for both the SPMP as well as the dynamic SM. The objectives to construct such a Conceptual Model and their expected benefits are as follows;

Objective 1: It is aimed to develop a model that incorporates internal and external environmental conditions of the companies to their SP and PM practices. While internal conditions reflect the level of resources and capabilities of the companies, external conditions represent the politic, economic or market factors surrounding them. While these conditions form the strategic positions of the companies, they also give signs about their future strengths or opportunities under diverse scenarios. The Conceptual Model is aimed to include such conditions to comprehend RBV inherent in strategies made, dynamic capabilities developed from these resources, or organizational boundaries, external trends and uncertainties surrounding the companies.

Objective 2: It is aimed to develop a model that enables company-level PM rather than solely focusing on performances of single project. The Conceptual Model is aimed to include corporate-level strategies and performance measures by also supporting strategies at different organizational levels such as corporate, single business stream/unit, or profit centers (i.e. projects). Through linkages among all strategy levels, it is aimed to cascade down the strategies simply those taken in the corporate level to the lower organizational hierarchies.

Objective 3: It is aimed to develop a model that reflects industry-based characteristics in PM practices via including both financial and non-financial measures. It is aimed to modify the original BSC in order to ensure industry-specific conditions of the construction industry are considered in SP and PM. A novel BSC is structured for construction industry specifically, which adds perspectives such as "sustainability", "stakeholder", "market and business growth", "governance and compliance" and "project management". In addition, a KPI framework (KPI-F) included in the BSC is aimed to provide both financial and non-financial KPIs applicable to construction industry. As is suggested by [133], the (KPI-F) is expected to provide clear and precise distinctions for measures utilized for different project tasks or attributes.

3.3.2. Computerized Model

Objective 4: It is aimed to develop a model that enables to balance the strategies through taking into account of the relative importance among resources and strategies. It is aimed to define the relative importance among KPIs included in the BSC to "balance" the perspectives properly. The weights of KPIs are captured in GMB sessions conducted with Company Experts. As part of this objective, it is aimed to develop an assessment methodology with which measures included in the SM are autonomously aggregated and quantified.

Objective 5: It is aimed to develop a model that considers interdependencies among performance measures included in SM. The causalities among these measures are represented as feedback loops to reflect bi-directional characteristic of their dependencies. In this regard, SD method is utilized to construct and assess causalities as it can handle real life non-linear problems ([67], [39], [32]).

Objective 6: It is aimed to develop a model that helps to understand the strategic relevancy of performance measures to the strategies defined previously. As also claimed by [285], the confusion of decision makers on priorities or descriptions of KPIs inherit in traditional PM methods can be overcome through incorporating them at the early times. Thus, it is aimed to involve Company Experts early in the process such as when defining KPIs to ensure relevancy of KPIs to the overall strategy. It is also aimed to develop KPI selection criteria in order to assess and refine KPIs in a systematic and structured way. As further named as “attributes”, these criteria are expected to overcome the problem of “relying on too many measures” ([132], [170]).

Objective 7: It is aimed to develop a model that has simulation capabilities to understand dynamic behavior of the strategy and enhance the quality of the strategic decisions made. To do so, a Computerized Model incorporated with SD method is needed to simulate KPIs through simple and single interfaces. Using the Computerized Model, it is expected to accommodate the changes in strategic environment to understand the dynamic behavior of the strategy as well as utilize the model as a testing mechanism for strategic options via model simulations. In this regard, simulation capability of the dynamic SM is beneficial for training in strategy making and testing diverse business scenarios prior to finalizing the strategies [53].

Objective 8: It is aimed to develop a model that supports decision-making process of experts in SP by providing means to handle subjectivity and cognitive biases. First, it is aimed to enable guidance and support in SPMP by providing some set of generic frameworks to the decision makers. The development of PESTBEL Framework (PESTBEL-F), Resources and Capability Framework (RC-F) and KPI-F, is expected to enable Company Experts some structured frameworks and taxonomies in decision-making process. It is aimed to minimize the cognitive and mental biases as well as subjectivity inherit in the process through facilitation of single set of supporting materials, which are further embedded in the model. In addition, some structured and consecutive GMB Sessions are conducted to provide a collaborative thinking environment when making decisions. GMB Sessions, which are also named as “Workshops”, are aimed to overcome the problem of reliance on top-down hierarchy when assessing performance and to overcome ignorance of participative communication among decision makers [297].

CHAPTER 4

RESEARCH METHODOLOGY

This chapter explains the research methodology by firstly describing steps of SPMP. It also introduces the Company collaborated in GMB Sessions, along with its major competitive advantages, as well as current SP and PM practices. In its forthcoming sections, this chapter explains the methodology undertaken in the context of GMB Session conducted with the Company. The final section describes the Stella Architecture tool, which was used when developing Computerized Model based on SD method.

4.1. STRATEGIC PERFORMANCE MANAGEMENT PROCESS

In line with the Research Design explained in Chapter 3.2, SPMP was taken as basis when developing the model. As explained in Chapter 2, the current literature is rich in various strategic management process ([100], [11], [53]). Based the process proposed by [53], in this study a four-step SPMP was developed namely; 1) strategic positioning, 2) strategy formulation, 3) strategy implementation, 4) strategy testing. The IDEF Diagram of SPMP is depicted in Figure 4.

Step 1 - Strategic Positioning: Similar to [11] and [53], the first step of the SPMP is "Strategic Positioning" in which internal and external conditions are scanned. This step contains external and internal environment analyses, which are further utilized when developing probable future scenarios for the construction industry. External environment analysis is about assessment of the external conditions via PESTBEL-F, which is introduced in Chapter 5. The framework includes both global and market related factors, which are classified in political, environmental, social, technological, business, economic and legal dimensions. Internal environment analysis refers to the assessment of internal conditions via RC-F, which is again introduced in Chapter 5. The framework includes both tangible and intangible assets, resources and capabilities of construction companies. Both frameworks are utilized in conducting SAP (given in Chapter 5), developing Conceptual Model (given in Chapter 6), developing Computerized Model (given in Chapter 7), testing the Computerized Model (given in Chapter 8) and simulating it under diverse scenarios (given in Chapter 8).

Step 2 - Strategy Formulation: The second step of the SPMP is "Strategy Formulation" in which probable strategic objectives are defined based on the internal and external analysis conducted in previous step. As explained in Chapter 5, a Strategic Objectives Taxonomy (SOT) is developed and used when developing a Strategy Map Structure (SMS). The SMS is based on the original SM developed by Kaplan and Norton [76]. In addition, to transform static SMS into a dynamic nature the "Scenario-Based Strategy Mapping" method proposed by [50] is used. In addition to [2], the study of [50] is also taken as reference during Strategy Formulation step. The outcomes of this step are SOT and SMS that are given in Chapter 5. This step also refers to the "strategic choice" step given in the process of [53], which is about developing the basis for future strategies.

Step 3 - Strategy Implementation: The third step, Strategy Implementation, is about translating the strategic objectives defined in the "Strategy Formulation" step into some operational terms. To do so; KPIs reflecting the operational terms of each strategic objectives of SMS and SOT are identified through a content analysis on literature. These KPIs are further formed into a KPI-F as given in Chapter 5.4. KPI-F is the description of how the company can translate and implement its strategic objectives. This step also refers to the "Strategy in Action" step given in the process of [53], which is about implementing strategies in order to ensure the defined and implemented strategies are working well in practice. After the development of KPI-F, the Conceptual Model of the BSC is constructed by incorporating PESTBEL-F and RC-F. The theory of "future scorecard" proposed by [2] is also taken as basis in order to add "future thinking" for the traditional BSC developed by Kaplan and Norton.

Step 4 - Strategy Testing: The forth step, Strategy Testing, is about assessment of the performance results and strategic fit of the organization in terms of given resources and capabilities as well as external conditions. To do so, the Conceptual Model is converted into a Computerized Model by using Stella Architecture, a SD modeling tool. The Computerized Model can be facilitated for simulating of future performance, evaluating of current and future strategic alignment of the organization or making decisions on the most crucial resources and capabilities to invest. Chapter 6 explains Computerized Model, Chapter 7 explains verification and validations test undertaken to ensure validity of the Model and Chapter 8 gives findings of simulation of Computerized Model in testing scenarios and strategies.

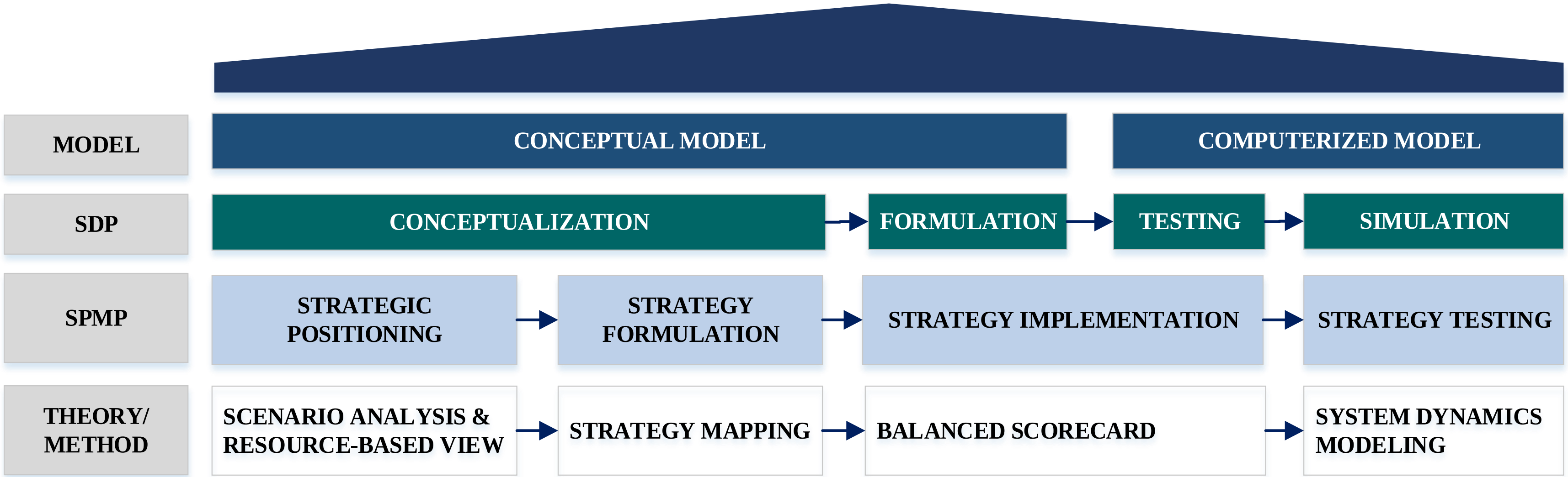


Figure 3: Strategic Performance Management Process Model (SPMP)

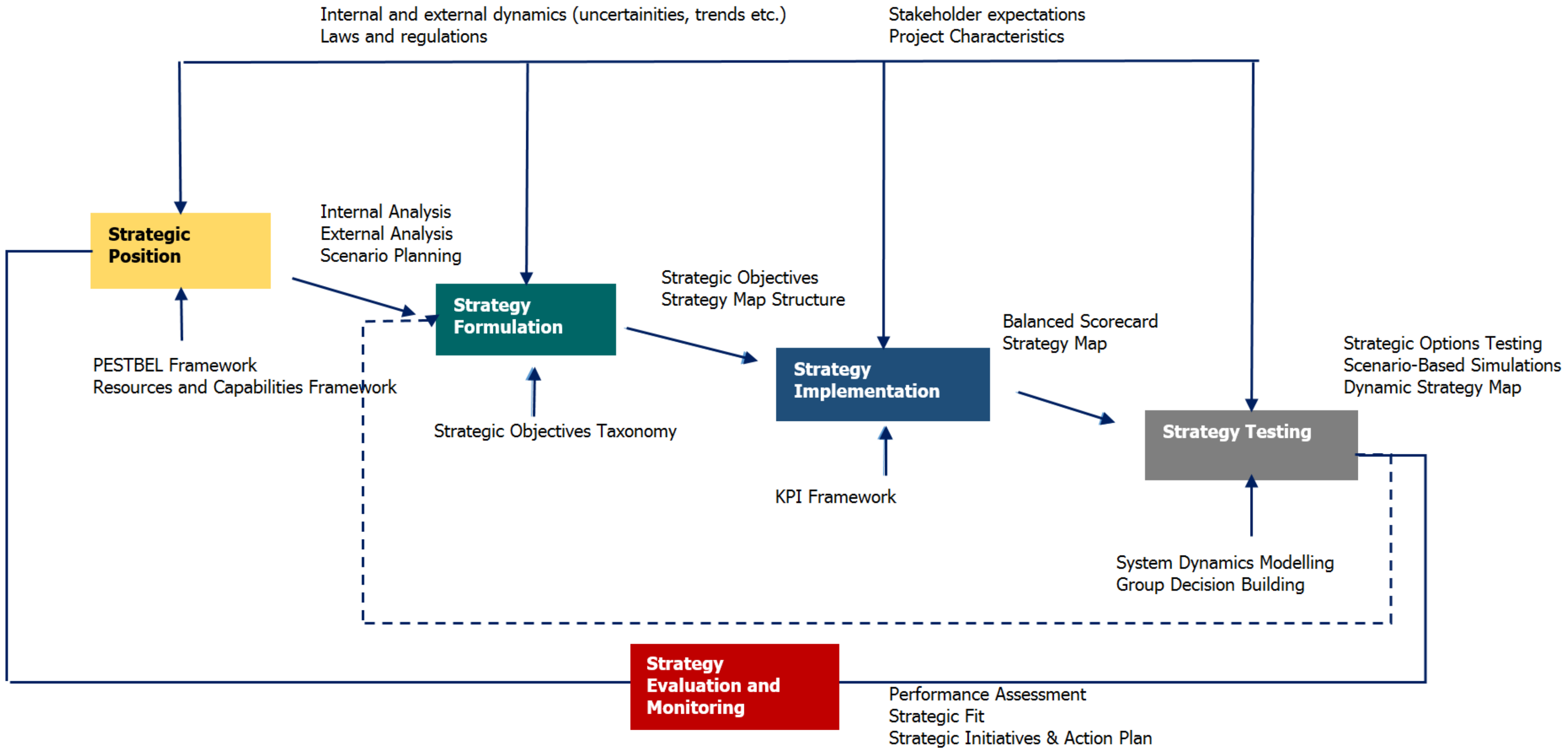


Figure 4: IDEF Diagram for Strategic Performance Management Process

4.2. RESEARCH METHODOLOGY

This research is conducted in five concurrent phases namely; 1) development of the Research Design, 2) development of the Conceptual Model, 3) development of the Computerized Model, 4) validation of the Computerized Model and 5) simulation utilizing a real case.

As introduced previously, one of the major novelty of this study comes from facilitation of SD in development of BSC and dynamic SM. Each phase of the research methodology is associated with steps of SDP and SPMP. Although the studies undertaken in each step are same, they refer to the different methodological phases of SD and SPMP. As explained previously, the underlying theory of SD conducted in this study composed of four phases; 1) conceptualization, 2) formulation, 3) testing and 4) simulation. The SPMP methodology however, consists of four other phases, 1) strategic positioning, 2) strategy formulation, 3) strategy implementation and 4) strategy testing. For example, Phase 2 is about Conceptualization step of the SDP, it is also about Strategic Positioning and Strategy Formulation of the SPMP.

The phases of the research methodology along with the steps of SDP and SPMP are summarized in Table 1.

Table 1: Overview of the Research Phases

Research Phase	SDP	SPMP	Chapter	Theoretical Basis
Phase 1: Development of the Research Design	-	-	Chapters 2- 4	
Phase 2: Development of the Conceptual Model	Conceptualization	Strategic Positioning Strategy Formulation	Chapter 5	[53], [2], [4], [4]
Phase 3: Development of the Computerized Model	Formulation	Strategy Implementation	Chapter 6	[76], [50], [77], [78], [61]
Phase 4: Validation of the Computerized Model	Testing	Strategy Implementation	Chapter 7	[4], [4]
Phase 5: Simulation Utilizing a Real Case	Simulation	Strategy Testing	Chapter 8	[79], [80]

Table 8 demonstrates the research methodology along with its phases, steps undertaken in each phase, methods utilized, and findings of each step. As given in Table 8, the aim of Phase 1 is to develop a Research Design along with defining research objectives and methodology. This phase is arranged in three steps namely; Review on the Theoretical Background (Step 1), Identification of Research Objectives (Step 2) and Development of the Research Methodology (Step 3). The findings of each step are given in Chapter 2, Chapter 3 and Chapter 4, respectively. As described in previous chapters, research objectives are defined based on the limitations of current literature in the field of SP and PM.

Chapter 4 also describes the Company through explaining its competitive advantages, SP and PM practices. As will be described in forthcoming chapters, serial GMB sessions are conducted with the Company Experts to fulfill two major purpose; first to validate the findings of each step, second to customize the findings to the Company. The detailed explanations of the each session along with some session attributes (i.e. input materials, session agenda, duration, participant profiles) are introduced at the end of the each chapter. This phase also explains the theoretical basis of the both Conceptual and Computerized Models. During the model development, the strategic management process proposed in [53] is taken as reference point. In addition, the study of [2], [4], [50] and [61] are used when incorporating future thinking to the model, developing external and internal scenarios to create dynamic BSC, as well as representing the causalities inherit in SMS. In addition, SD method is used to add dynamic and flexible nature to the SMS and to simulate the SMS based on diverse future scenarios.

Phase 2 is carried out in nine steps to develop Conceptual Model, which is described in Chapter 5 in detail. Based on the study of [2], one of the aim of Phase 2 is to develop future scenarios for construction industry based on future trends and barriers in global and market environment. To do this, firstly a content analysis is performed from a pre-developed theoretical base. Theoretical base constitutes construction future reports, industry reports and reports of excellence initiatives found by the researcher. Theoretical base is reviewed, classified and analyzed to capture the future trends and barriers; those are further utilized when developing SOT in Step 8. In the context of Step 6, PESTBEL-F is developed, consisting factors in Political, Economic, Social, Technological, Business, Environmental and Legal dimensions both in global and in market environment. By using PESTBEL-F, SAP is undertaken in the context of Step 7. Based on the findings of Step 7, a GMB session is conducted with the Company Experts to assess and formulate future scenarios for the construction industry. Three probable scenarios, those representing the most likely, least likely and mean, are selected as a basis for forthcoming phases based on the mental models of the Company Experts. In the context of Step 6, the RC-F is also developed for both strategic positioning and resource accumulation purposes, representing stocks and flows in SD modelling.

Phase 2 is followed with defining generic strategic objectives for the construction industry. Strategic objectives are constructed as in the form of a taxonomy, for which a secondary content analysis is performed in Step 8 based on the theoretical base developed in Step 5. After a review on the base and extracting the key words, SOT is developed in Step 8, which is utilized as a session input during Session 2 conducted with the Company Experts in Step 9. While defining a generic SOT, the study of [306] is taken as a reference point, who proposed a simple and systematic method for identifying strategic objectives facilitated in traditional SMs.

The aim of Step 9 to 12 are to develop a BSC and SMS as well as customize it for the Company again based on the mental models of the Company Experts. In the context of Step 9, a SMS is developed based on the findings of Step 8. During Step 9, the study of [2], the BSC of [1], SM of [76] and scenario-based strategy mapping proposed by [50] are taken as reference studies. In order to validate the SM, Session 2 is conducted by the Company Experts also in the context of Step 9. During the session, the SMS is introduced, discussed and modified by the Company Experts. Experts made modifications to the preliminary BSC and SM based on the scenario requirements and realities of the Company.

Based on the finalized SMS in the context of Step 9, it is aimed to develop KPIs in order to construct a BSC Structure. First, attributes reflecting the contextual characteristics of KPIs are developed first in Step 10. These attributes are further utilized as a decision-making and assessment technique when refining and selecting the KPIs specific to the Company in Step 11. In addition, KPI-F is developed in the context of Step 10, through making content analysis on benchmarking and excellence initiatives in construction industry. Some of these initiatives are; Global Reporting Initiative (GRI), KPIs in the United Kingdom (KPI- UK) [145], Construction Industry Institute Benchmarking and Metric (CII) [144], Glenigan UK Industry Report (GLENIGAN) [307], and National Benchmarking System for the Chilean Construction Industry (NBS- Chile) [154].

After the KPI–F is developed, Session 3 is conducted with focus groups selected from the Company in the context of Step 11. Different from previous sessions, focus groups are formed by director-level specialists rather than C-level managers. This is partly due to two major reasons; first, selection and assessment of KPIs takes longer time while compared with other sessions, and it is not possible to take that amount of time of C-level managers of the Company. Second, KPIs are more operational-level rather than strategic, thus CEO of the Company suggested to take opinions of director-level specialists having operational roles. So that; seven focus group interviews are undertaken for seven BSC perspectives separately with the director-level specialists on each perspective. These interviews are all regarded as Session 3. During these interviews, it is expected from focus groups to discuss the KPIs, add, modify, or delete KPIs based on group consensus, as well as assess KPIs based on pre-defined attributes. To be noted, attributes are given as a structured list in order to ensure the simplicity and understandability of the session. Finally, KPIs specific to the Company are selected based on attribute ratings. The selected KPIs are further utilized to develop BSC Structure of the Company.

As explained in Chapter 6, Phase 3 is about development of the Computerized Model in the context of Formulation step of the SDP. It is about applying SD in SPMP via developing a Computerized Model for SM. To do so; this phase is carried out in four steps namely; Development of the Computerized Modeling Process (Step 13), Development of the Model Assumptions and Boundary Conditions (Step 14), Validation of the Model Assumptions (Step 15), and Development of the Stock-Flow Diagrams of the Model (Step 16). During Step 13, the formulation process of the Computerized Model is theoretically defined based on which the Computerized Model is developed and formulated. Step 14 is about development of the model assumptions, which are needed to formulate model. As a further effort, Session 5 is conducted with the Company Experts in order to review, discuss and validate the model assumptions based on the decisions and judgements of the Experts. This Session is crucial as it provides elimination of the individual subjective judgements of the researcher on the assumptions as well as ensures the simulated model will behave in line with the real system models. After the model assumptions are finalized, the SFD of each BSC perspective are developed to construct the Computerized Model in Stella Architecture.

Phase 4 is about verification and validation of the Computerized Model in the context of "Testing" step of the SDP. As explained in Chapter 7 in detail, aim of the "Testing step is to ensure a) structural validity, b) behavior validity and c) operational validity of the computerized model. This step is critical as it ensures whether the model is working in line with its purpose and produces right behavior at the right time [308]. In this regard, Chapter 7 initiates with a brief overview of the literature on the importance and methods of SD verification and validation. This phase is conducted in two steps namely; development of model validation process and structure (step 17) and conducting model validation tests (step 18). In this context, first a Model Validation Process and a Model Validation Structure are developed based on the available literature conducted in Step 17. Based on the Model Validation Process and the Structure, some set of validation and verification tests are conducted by the researcher. These tests are; a) dimensional consistency test, b) boundary-adequacy test, c) extreme-conditions test, d) parameter-verification test, e) behavior anomaly test, and f) assumptions sensitivity testing. As a further step, a Face Validity Test is conducted by the Company Experts in Session 6 in order to capture the opinions of the Company Experts about the structural, behavioral and operational behavior of the Computerized Model. During Phase 5, the Computerized Model developed in Stella Architecture is facilitated throughout tests.

Phase 5 is the last phase, which is about simulation of the computerized model in the context of "Simulation" step of the SDP. As explained in Chapter 8 in detail, simulation is a process of driving a model of a system with suitable inputs and observing the corresponding outputs [309]. It could be used in the choice or matching phase of strategy-making [310]. This phase is conducted in two steps namely, conducting scenario testing (step 19) and strategic options testing (step 20). As explained in Chapter 8 in detail, aim of the simulation step is to a) conduct scenario-based PM in Scenario Testing, and b) test different strategies in Strategic Options Testing, in the context of "Strategy Testing" step of the SPMP. To do so, firstly the baseline conditions are gathered from the Company Experts in the form of qualitative and quantitative input data in Step 18 as well as imported to the Computerized Model as the baseline scenario. As a further approach, input data are also defined by the Company Experts for the three scenarios developed in Step 7. Then, Scenario Testing is conducted with the Company Experts by utilizing scenario-based input values in the Computerized Model in Stella Architecture, in Session 7. Scenario Testing resulted in generation and comparison of simulation results for three scenarios. Chapter 8 also reports the Strategic Options Testing conducted with the CEO of the Company in Session 8. During this session, baseline conditions are utilized to analyze strategic achievement of the Company with its real performance. Through conducting Strategic Options Testing, it is aimed to enable a decision support tool for the Company CEO when making strategic decisions.

As summarized in Table 9, three major research methods are facilitated throughout the study. First method is about elicitation of theoretical knowledge through structured content analysis on available literature. In this context, first a content analysis on construction future studies is performed when developing PESTBEL-F and RC-F in Step 6, and SOT in Step 8. A separate review is also performed on reports of benchmarking initiatives to develop KPI–F in Step 11.

Second method is about conducting numerous research sessions with the Company Experts. The sessions are undertaken in three forms; a) GMB sessions with Company Experts, b) Strategic Options Testing through a real case study with Company CEO, c) Focus Group Interviews with director-level specialists. First group, workshops sessions are conducted via GMB technique in which cognitive models of the diverse participants are incorporated. Workshop sessions are facilitated when conducting scenario analysis (Step 7) in Session 1, validating the developed SMS (Step 9) in Session 2, selecting company-specific KPIs from KPI-F (Step 11) in Session 3, validating the SMS (Step 12) in Session 4, validating model assumptions (Step 15) in Session 5, and conducting model validation tests (Step 18) in Session 6. Focus Group Interviews are conducted in Session 3 with director-level specialists to assess KPIs in the context of Step 11. At last, Scenario Testing is carried out with C-level executives in Step 19 in the form of Session 7 as well as Strategic Options Testing is facilitated with Company CEO through a real case in Step 20 in the form of Session 8. A brief overview of the Company, profile of the Company Experts and methodological aspects of the sessions are explained in Chapter 4.2 and Chapter 4.3.

Third method is the facilitation of a computerized tool for the development of a Computerized Model. To do so, available commercial tools are searched from the internet; some available tools are examined in detail through trial versions of these tools. After detailed examinations, Stella Architecture of the isee Company is valued as the most appropriate tool for the research purpose. Stella Architecture is purchased as “PhD student version” as well as utilized when developing the Computerized Model (Phase 3), testing model validation (Phase 4), and simulating the Computerized Model utilizing a real case (Phase 5). An overview on the isee Company and Stella Architecture tool are given in Chapter 4.4.

Table 8: Summary of the Research Methodology

Phases	Steps	GMB Sessions	Methods	Related Chapter	Outputs
Phase 1: DEVELOPMENT OF THE RESEARCH DESIGN	**Step 1:** Review on the Theoretical Background	-	Method 1	Chapter 2	Theoretical Background
	Step 2 : Identification of Research Objectives	-	Method 1, Method 2	Chapter 3	Research Theoretical Basis Research Objectives
	Step 3: Development of the Research Methodology	-	Method 1, Method 2	Chapter 4	Research Design Research Methodology
Phase 2: DEVELOPMENT OF THE CONCEPTUAL MODEL	**Step 4:** Development of the Conceptual Modeling Process	-	Method 1, Method 2	Chapter 5	Conceptual Modeling Process
	Step 5: Review on Construction Future Literature		Method 1	Chapter 5	-
	Step 6: Development of the PESTBEL and RC Framework	-	Method 1	Chapter 5	PESTBEL & RC Framework PESTBEL & RC SWOT Indicators PESTBEL for Scenario Storylines
	Step 7: Development of Future Scenarios	Session 1	Method 1, Method 2, software	Chapter 5	Scenario Formulation Matrix
	Step 8: Development of Strategic Objectives Taxonomy	-	Method 1	Chapter 5	Strategic Objectives Taxonomy
	Step 9: Development of the Strategt Map Structure	Session 2	Method 1	Chapter 5	Strategy Map Structure
	Step 10: Identification of KPI Framework	-	Method 1	Chapter 5	KPI Attributes KPI Framework
	Step 11: Assessment of KPI Framework	Session 3	Method 2	Chapter 5	Balanced Scorecard Structure
	Step 12: Development of the Balanced Scorecard Structure	Session 4		Chapter 5	

Phase 3: DEVELOPMENT OF THE COMPUTERIZED MODEL	**Step 13:** Development of the Computerized Modeling Process	-	Method 1, Method 3	Chapter 6	Computerized Modeling Process
	Step 14: Development of the Model Assumptions and Boundary Conditions	-	Method 3	Chapter 6	Model Assumptions
	Step 15: Validation of the Model Assumptions	Session 5	Method 2, Method 3	Chapter 6	-
	Step 16: Development of the Stock-Flow Diagrams of the Model	-	Method 3	Chapter 6	Computerized Model
Phase 4: VALIDATION OF THE COMPUTERIZED MODEL	**Step 17**: Development of Model Validation Process and Structure	-	Method 1, Method 3	Chapter 7	Model Validation Structure
	Step 18: Conducting Model Validation Tests	Session 6	Method 1, Method 2, Method 3	Chapter 7	Behavior Adequacy Test Findings Extreme Conditions Test Findings Behavior Abnormally Test Findings Assumptions Sensitivity Test Findings Model Modifications Face Validity Scoring Test Findings
Phase 5: SIMULATION UTILIZING A REAL CASE	**Step 19:** Conducting Scenario Testing	Session 7	Method 2, Method 3	Chapter 8	Scenario Test Findings
	Step 20: Strategic Options Testing	Session 8	Method 2, Method 3	Chapter 8	Strategic Options Test Findings

Table 9: Summary of the Research Methods

ID	Method Type	Source
Method 1	• Content Analysis on Construction Future Studies • Content Analysis on Benchmarking Initiatives	Content Analysis on Literature
Method 2	• Group Model Building Workshops • Focus Group Interviews • Scenario Testing • Strategic Options Testing	Company Participation
Method 3	• System Dynamics Software- Stella Architecture	Computerized Tool Facilitation

4.3. CASE COMPANY

This research is conducted with the collaboration of a Turkish international construction company. The Company is one of the largest domestic and international construction firm in Turkey, being consistently ranked in top construction firms in Engineering News-Record (ENR) 250 [81]. As given in IFRS report of the company, total assets of the Company has reached approximately 10 billion USD at the end of 2017.

As given in company website, the Company furnishes services as the main contractor and investor in more than 15 countries throughout the world. The company mainly operates in construction, real estate development, energy, heavy industries, and health sectors. The Company currently constructs various type of projects such as offices, shopping malls, hotels, houses and building complexes, heavy industry plants, infrastructure plants, chemical and pharmaceutical plants, automotive and machine factories, health complexes and hydroelectric power plants. The company completed more than 700 projects. By employing more than 50.000 employees as of 2017, the Company is one of the flag carrier Turkish contractor companies doing contracting business throughout the world.

4.3.1. Competitive Advantages of the Company

Main sources of competitive advantages of the Company are explored and captured by the researcher by making a review on the reports published by the Company. These reports include; Communication on Progress Report submitted to the UN Global Compact, Sustainability Report submitted to the Global Reporting Initiative as well as Annual Report and IFRS Report declared in the Company website. All reports are prepared and published as of year 2017.

After a review on these reports, competitive advantages of the company are explored as follows. To be noted that, these competitive advantages are also discussed and validated within an unstructured interview session made with the Company CEO.

a. **Building Information Modelling:** The Company utilizes the Building Information Modelling (BIM) method throughout its design and construction processes. Their BIM practices start with 3D Modelling in which building components are defined as “intelligent objects” based on which 4D modelling is facilitated for scheduling purposes. Based on the 4D models, the company also facilitates 5D modelling for quantity take-off and cost estimation. Some strategic initiatives of the company in BIM utilization are, a) investigating and developing the best practices and techniques about BIM, b) organizing training and education programs, c) providing in-house consulting services.

b. **Lean Construction:** The Company has focused on Lean Construction to maximize the value offered by its projects and minimize the waste. Company Experts mentioned that; lean construction provides minimizing waste by eliminating the non-value added processes as well as enables identifying the probable problems and nonconformities in the early stages of projects. With the incorporation lean construction, the company has strengthen its capability of identifying the “value” from the client point of view.

c. **Engineering Procurement and Construction (EPC):** The Company has various EPC projects to deliver the projects in best design possible, in lowest cost, in highest efficiency and in most effective cooperation. Company CEO states, “Through EPC contracting, we ensure safe delivery of projects as EPC provides effective cooperation and joint efforts of project stakeholders”. The Company utilizes EPC as a strategic initiative tool when entering into joint venture (JV) and consortium agreements with other international EPC contractors.

d. **In-house Design and Engineering Capability:** The Company provide a wide range of engineering services in design, procurement, construction and commissioning phases by experienced senior engineers and young specialists. The major strategic initiatives of the Company in in-house design and engineering capability are; a) employing skilled and talented designers and engineers, b) utilizing best practices in the industry, c) applying latest technology such as utilizing the most efficient design and engineering software.

e. **Integrated Project Delivery:** With the incorporation of integrated project delivery, Company created a business environment in which the early involvement of project participants are ensured as well as their knowledge and experience are shared. Business principles of the Company in the context of Integrated Project Delivery are; a) mutual respect and trust, b) collaborative working and decision-making, c) transparent, open and clear communication, d) knowledge dissemination and sharing, and e) early and continuous involvement of project participants.

d. **Technological Capability and Innovation:** Company classified its information systems and technical capabilities under five folds; network, information security, application development, helpdesk, Enterprise Resource Planning (ERP) and business intelligence. Some strategic initiatives of the Company are; a) making global partnerships with worldwide technology providers, b) establishing a dedicated ICT team, c) adopting ERP systems throughout the projects, d) adopting communication technologies such as voice conferences, video demonstrations, e) installing webcams on construction sites as real time visual controls, f) keeping up with the latest trends and level of technologies.

e. **Occupational Health and Safety (OHS):** Company strictly fosters for “Zero Accident” throughout its projects. Some strategic initiatives of the company to enhance OHS are; a) continuous trainings on OHS, b) conducting OHS risk assessments, c) setting mitigation and prevention actions, d) adopting zero-accident culture throughout its projects, and e) rewarding successful OHS practices exhibited by its employees.

f. **Corporate Social Responsibility (CSR):** Some strategic initiatives of the company to enhance its CSR are, a) ensuring OHS of their employees, b) protecting the environment, c) conducting the business in an ethical manner, d) promoting local economies, and e) supporting the social life of people. The Company also supports various social activities in the field of health, sports, culture, arts and science.

g. **Business Ethics:** The Company is committed to its Code of Conduct, which is developed in accordance with its ethical business principles, laws and regulations. The Code of Conduct describes the corporate values of the Company towards business ethics. The Company expects all its stakeholders (i.e. suppliers, subcontractors, employees) to do business in accordance with ethical values.

h. **Quality Assurance and Quality Control (QA & QC):** The Company is committed to ensuring highest quality standards in its projects. Some strategic initiatives of the company are; a) establishing a defect identification system to prevent probable defects at the early stages of projects, b) establishing a quality management system, c) developing a structured quality management organization, d) conducting QA&QC audits to explore any non-conformities to the contractual terms and conditions, organizational procedures, standards, or any other local legal obligations.

i. **Skilled Human Capital:** The Company is also committed to improving the technical and managerial skills of its employees through some set of HR tools. Some of these tools are; a) professional development and career growth plans, b) education and training programs and c) other learning opportunities.

j. **Sustainability and Green Building:** The Company supports sustainability to ensure human health and protect natural resources, environment and cultural heritage. The Company is strictly committed to complying with national and international laws, regulations and standards associated with environmental protection and resource consumption. The Company has established a structured environmental management system to assess and reduce greenhouse gas emissions, waste production, and energy and water consumption. With its “sustainability culture” from beginning of design to the end of operation, various projects of the Company has also acquired the right to obtain LEED (Leadership in Energy and Environmental Design) certificate by the United States Green Building Council (USGBC).

4.3.2. Strategy and Performance Management System of the Company

Performance Management System of the Company: The Company is developed a well-defined and process-based PM system. As part of their PM system, each year, C-level directors of the Company develop KPIs based on their yearly business plan. After identifying KPIs at the beginning of each year, they are assessed two times per year; at the mid-term and at the end of the year. The Company also utilizes a software tool to keep the results of these assessment periods. Throughout the sessions conducted, the verbal statements of the Company Experts revealed that PM is also utilized as a tool for strategic alignment. However, the true and systematic link between performance and strategic management is rather limited, reflecting there is a room for improvement in this area.

Strategic Management System of the Company: Oppose to the PM system of the Company, strategic management system of the Company have not defined yet as in the form of a structured-process. Throughout the sessions conducted, the verbal statements of the Company revealed that the strategic decisions are generally stored in the “cognitive mental models” of top management. However; while the annual reports of the Company are reviewed, it is understood that the Company uses three strategic management method, namely; a) carrying out SWOT analysis, b) developing Strategic Business Plan, c) defining vision and mission statements. First, the Company periodically undertakes SWOT analysis to scan their external environment with which probable risks or threats are defined, that may occur in markets they operate. Second, the Company prepares its Strategic Business Plan at the end of each year for the following year. The Strategic Business Plan includes information about 5-year strategy of the Company as well as strategic objectives supporting the 5-year strategy. With also contributing to its strategy, the Company also defined numerous other strategic objectives such as ensuring QA&QC, fostering for sustainability, maximizing tendering performance. As another strategic management tool, the Company has a well-defined and understandable vision and mission statements, which are periodically communicated to the employees via both digital, verbal and written platforms.

Some improvement areas for the current strategy and PM practices of the Company are listed in Table 10.

Table 10: Improvement areas about current PM practices

ID	Limitation
Performance Management	**A standard KPI list is not developed or used by the Company.** Although KPIs are defined at the beginning of each year, the Company does not use any standard KPI list or a database in this process. There is a probability that, KPIs are defined differently for each project based on the mental models of their Project managers. However, using different KPIs among projects limits any benchmarking efforts, consolidation of PM results or sharing best practices among projects due to measuring different fields.
Performance Management	**Assessments could not be made automatically and measurement equations are rather poor.** Although the Company utilizes a software tool in PM process, the tool only enables to keep the assessment results rather than directly supporting the assessment process. The tool could not quantify KPIs automatically based on the defined input values. Thus, assessment process is highly based on the subjective judgements or manual calculations of the company employees.
Performance Management	**Interdependencies among KPIs are ignored.** KPIs are defined as separate measures, ignoring any interdependencies among them. This is mainly due to two reasons; firstly as the assessment of these measures are based on manual calculation of employees, any complexity involved in the process (such as considering interdependencies among measures) could not be handed by human mind. Second, the true link among KPIs and their dependencies could not be easily identified by the employees, as experience and knowledge of them vary, leading to different interpretations about dependencies.
Performance Management	**The results of the performance assessment are not systematically used in strategy management.** Although KPIs are defined based on the strategic business plan of the Company at the beginning of each year, the findings of these KPIs obtained at the end of year, are rather poorly incorporated and considered when developing business plan of the following year. In addition, there is no control mechanism about whether strategies defined in business plans are fully translated into the operations terms via KPIs. Thus, there is a risk of omitting or forgetting to define any KPIs associated with the any strategies.
Strategic Management	**The results of SWOT analysis are not systematically used or considered in PM or other strategic management practices.** Although the Company analysis both its internal and external environment through SWOT analysis, there is not any proof of whether the results of the SWOT are used in any other PM or strategic management practices. For example, it is understood that for the projects undertaken in different regions, similar KPIs are defined with similar targets, neglecting the effect of results of the SWOT on the KPIs or its targeted values.
Performance Management	**Lack of a decision support mechanism both in PM and strategic management practices.**

	The mental models of the top management of the Company mainly shape strategies. Although, PM results or SWOT analysis results can be used during this process, any structured process or method is lack to support their decision-making process or enhance decisions made. For example, there is not any tool to test the strategies by simulating their probable implications for the Company, before they are implemented.

4.3.3. The Role of the Company in this Research

As explained previously, the role of the Company to this research can be summarized in four major efforts;

1) **Identification of Initial Requirements:** The reports of the Company are analyzed by the researcher in order to capture initial requirements prior to the development of the Conceptual Model. These reports include UN Global Compact Report, Annual Report, Sustainability Report and IFRS Report of year 2017 published in the Company website. After the reports are analyzed, two findings are obtained by the researcher; first main competitive advantages of the Company, second initial requirements of the Company in the context of SP and PM. To do so; an unstructured interview session with the Company CEO is also arranged prior to the any research developments. The interview is arranged for three major purposes;
    a. Validate the competitive advantages of the Company, that are captured by making a brief review on the company reports by the researcher
    b. Identify current practices of the Company in the context of SP and PM as well as discuss rooms for the improvement,
    c. Give brief information about the research design as well as capture requirements of the Company CEO from this research
    d. Select the experts from the Company, who will participate in the GMB Sessions throughout the research.

2) **Development of the Conceptual and Computerized Model:** A serial workshop sessions are conducted with first group Company Experts in order to develop, test or validate findings of the diverse steps given in Table 11. Five workshop sessions (Session 1, 2, 4, 5, and 6) are conducted in this purpose, which are organized based on GMB method. In addition, a serial Focus Group Interviews (Session 3) are conducted with second group Company Experts in order to develop a company-specific SMS.

3) **Conducting Scenario Testing:** A Scenario Testing (Session 7) is conducted based on the quantitative and qualitative data of the Company in order to test and simulate the dynamic SM model.

4) **Conducting Strategic Options Testing:** A Strategic Options Testing (Session 8) is conducted with the Company CEO in order to test implications of the

diverse strategies on the KPIs as well as to understand how the model support and enhance strategic decision-making.

4.4. GROUP MODEL BUILDING SESSSIONS

The true benefit of SD model is achieved when the model produces "right behavior for the right reasons" [308]. Throughout the model development, it is needed to ensure the model is built for its intended purpose. Thus, to ensure both behavioral validity and the overall purpose, the model is developed with the participation of Company Experts throughout the SDP in serial sessions. In line with the work of [311], these sessions are conducted in the form of GMB technique.

Table 11 summarizes the sessions conducted in this research in terms of research phase, step and output generated after each session. These sessions are conducted in line with the SDP proposed in Chapter 4.1.

Table 11: Summary of the Group Model Building Sessions

Phases	Steps	GMB Sessions	Related Chapters	Outputs
Phase 2: DEVELOPMENT OF THE CONCEPTUAL MODEL	**Step 7:** Development of Future Scenarios	Session 1	Chapter 5	Scenario Formulation Matrix
	Step 9: Development of the Strategy Map Structure	Session 2	Chapter 5	SMS
	Step 11: Assessment of KPI Framework	Session 3	Chapter 5	Balanced Scorecard Structure
	Step 12: Development of the Balanced Scorecard Structure	Session 4	Chapter 5	
Phase 3: DEVELOPMENT OF THE COMPUTERIZED MODEL	**Step 15:** Validation of the Model Assumptions	Session 5	Chapter 6	-
Phase 4: VALIDATION OF THE COMPUTERIZED MODEL	**Step 18:** Conducting Model Validation Tests	Session 6	Chapter 7	Face Validity Scoring Test Findings
Phase 5: SIMULATION UTILIZING A REAL CASE	**Step 19:** Conducting Scenario Testing	Session 7	Chapter 8	Scenario Test Findings
	Step 20: Strategic Options Testing	Session 8	Chapter 8	Strategic Options Test Findings

[311] described GMB efforts with two dimensions; the structural and process dimensions, which also include several components ([312], [67]). Structural dimensions include group structure and logistics, which are about design of the group modelling efforts as well as the way they are conducted. However; process dimensions are oriented towards steps of traditional SD modelling process; namely; 1) Problem

Articulation, 2) Dynamic Hypotheses (Conceptualization), 3) Formulation, 4) Testing and 5) Simulation.

Based on the classification of [311], in this study, GMB sessions are designed with the consideration of these two dimensions. They are designed in a way that they are customized and conducted differently throughout the SDP, based on the requirements of each step. In this regard, firstly process dimensions are elaborated in “4.4.1. Process of Group Model Building Session” and then structural dimensions of these sessions are explained in “4.4.2. Design of Group Model Building Session” sections.

4.4.1. Process of Group Model Building Sessions

As given in Figure 3, SDP, developed in this study, consists of four steps namely; 1) Conceptualization, 2) Formulation, 3) Testing, and 4) Simulation.

Problem Articulation: As given in [311], the problem articulation activities are generally built with individual meetings with participants, that is, preparatory interviews ([313], [314]), or with small nominal groups [314]. Numerous techniques can be used to define the problem to be solved by SD, especially brainstorming tools [74]. However independent from which technique is facilitated, this first step of SDP mainly depends on divergent tasks in order to increase the quantity and diversity of ideas (i.e. ideas about the system boundaries) [314], and on visual aids such as graphs, maps, or diagrams, in order to support the process of knowledge elicitation. In this study, problem is defined through an in-depth literature review, whose findings are reported as in the form of Research Gaps. The findings of the review are also supported by a preliminary interview undertaken by the Company CEO as well as an initial analysis on the current practices of the Company in the field of SP and PM. During the interview, Company CEO is asked about the limitations of their current practices as well as their expectations from this study to handle these limitations. However; due to the confidentiality concerns the findings of the interview in the form of any verbal statement, could not be given in this thesis.

Conceptualization: Conceptualization step is highly associated with the process of knowledge elicitation and reaching a consensus among participants [311]. This step highly requires structured and systematized group activities, with the participation of experts on SD modelling and one or more facilitators ([314], [315]), [313]. [74] suggested to use preliminary influence diagrams to conceptualize the SD model, especially “if participants have no SD modelling experience, if the facilitator has only little experience in group model building, and if participants do not have enough time and/or are geographically dispersed”. According to [314], while the conceptualization of a system into influence diagrams can rely on divergent tasks for knowledge elicitation, the design of feedback structures is frequently executed through convergent tasks in order to discover courses of action [314]. In this sense, [316] recommended to firstly performing separate modelling sessions for each stakeholders group, to lessen the risk of limiting the points of view to one dominant stakeholders group. In this study, three GMB sessions are conducted to conceptualize the system to be modelled. The first two of the sessions are performed in the form of workshops with the participants representing C-level executives of the Company. The last sessions is conducted as separate focus group interviews with other group of participants to solicit knowledge based on expertise on diverse fields. The decisions made are largely involve convergent tasks in which establishment of a group consensus is one of the most challenging concern.

Formulation: Formulation step includes the design of a SFD of the model, the development of decision rules, the quantification and calibration of the model [311]. The design of a SFD is highly suggested to use in individual meetings with participants or on small nominal groups, as well as on structured and systematized group activities [314]. After the design of the SFD, [312] suggested to develop mathematical equations involved in any SFD with the entire group, while [317] put the emphasis on "limiting the tasks to key variables and relations, using the reference modes, and trying to formally capture the participants' reactions in order to refine the model". Subsequently, [318] suggested codification of expert knowledge, in order to estimate the model's parameters, the initial conditions of the model, and the interrelationships to be specified in the SFD. However, as discussed by various authors (i.e. [313], [319], [318]), due to the iterative nature of this step, crucial preparatory (off-site) studies from the modelling team [313] are needed in order to reduce the complexity. Thus, in most cases, this step is not carried out in front of the group of participants [319], making the model facilitators to undertake necessary studies off- site. As also highly discussed in literature, in this study, SFD of the model is designed and associated mathematical equations of the SFD are developed by the researcher as in the form of preparatory studies. However, the final design of the SFD, its equations and required model assumptions are discussed with the Company experts in a separate GMB sessions.

Testing: Testing is the fourth step in which some validation tests are carried out to ensure structural and behavioral validity of the simulation model. According to [311], these validation tests are mainly under responsibility of the modeling team, which do not require direct involvement of the participants. Thus, any GMB sessions might not be required, although it is generally suggested that its clients should also validate SD models. In line with the discussion of [311], in this study, validation tests are largely undertaken by the researcher through some set of tests offered in literature. However, a final Face Validity Test is conducted with the Company Experts in the form of GMB session after the researcher iteratively conducts whole tests.

Simulation: Simulation step is about development of scenarios and evaluation of simulated results over time. GMB is beneficial in simulation step in order to establish a consensus on the scenarios to be tested as well as decisions on strategies to be implemented [311]. In this study, two GMB sessions are conducted by the Company experts and Company CEO separately. The first session is about analysis of the simulation results under three scenarios, which is undertaken as in the form of "Scenario Testing". Second session is about decisions on strategies to be implemented by testing different strategies via SD model as well as evaluation of KPIs generated under these strategies. This session is carried out solely by Company CEO, as he is primarily responsible from defining strategies. This session, named "Strategic Options Testing" is also the last session undertaken in the scope of this study.

4.4.2. Design of Group Model Building Sessions

Throughout the SDP, eight GMB sessions are conducted with the Company Experts. First three sessions are about conceptualization phase of the SDP, fourth and fifth sessions are conducted for formulation purposes, sixth session for testing and finally seventh and eight session are towards simulation phase of the SDP. As mentioned previously, all sessions are designed through some set of structural components, which are developed in line with the components suggested by [311] and [312]. These structural components of the GMB sessions are listed in Table 12.

Based on these components, Session Information Cards (SIC) are developed for each session, which summarize them as in the form of their agenda, participants involved, risks faced or findings obtained. SIC of each session are given in this study, after associated steps of SDP are introduced. However; based on Table 12, firstly a brief knowledge about major structural components of the sessions are explained as follows.

Session Procedure: Group-modelling projects are typically carried out with participants who develop models and a facilitator who guide knowledge elicitation within the group in structured sessions [319]. These sessions are generally referred to as group modelling workshops, work sessions or conferences [311]. The participants are generally the “clients” for whom the model is developed as well as facilitators are the “researchers” who are specialized in the process. As suggested by [311], group modelling projects are largely encompass three stages of activities namely; pre-meeting activities, activities undertaken during the modelling sessions, and post-session or follow-up activities.

In line with the [311], in this study, a systematical methodology is followed during each session. The researcher (who is also facilitator), conducted some pre-sessions studies prior to workshop, to identify, assess and prepare the initial workshop materials. These materials are sent to the Company Experts prior to one week of the workshop day. During the workshops, group discussions are made in which verbal statements are captured by the researcher for post-session studies. The results of the workshop also studied by the researcher as a post-session study and sent to the Company Experts for validation. The agenda of each session is about different steps of the research, an overview about session agendas are given in Table 11. In addition; detailed description of sessions are given in forthcoming sections in the form of SIC; such as Session 1 in Table 22, Session 2 in Table 25, Session 3 in Table 37, Session 4 in Table 38, Session 5 in Table 41, Session 6 in Table 58, Session 7 in Table 61, and finally Session 8 in Table 62. The summary of the structural dimensions of these sessions are also given in Table 13.

The process of sessions are rapid, focused and structured, with the sessions being conducted in 2-5 hr. 23 experts are participated in eight sessions. One the major advantage of this process is the fast achievement of results and collaborative group decision towards model development.

Participant Size and Composition: Studies on group modelling has emphasized the importance of involving several participants in the modelling process, with the purpose of improving the relevance and usefulness of the model [74]. It also allows individuals to improve their mental models as well as provides groups to achieve a consensus on a system to be modelled [312].

There are various arguments in current literature about the size and composition of the groups. On the one hand, it is suggested that the number and diversity of participants possibly will have a positive effect on the usefulness of the model designed [320]. On the other hand, it is also accepted that communication among group participants decreases as the group size increases [314]. In addition, the management of large groups may trigger interpersonal relations and conflicts, which add an inhibition risk to the process [320]. Also, management of sessions involving large groups might require to use labor-saving techniques such as questionnaires, workbooks, structured workshops, and software support) [314].

In this study, 23 executives from various levels of the Company are participated in different GMB sessions. The background information of participants as well as their participation per session is given in Table 14. Although the number of participants is high, sessions are carried out with different sub-groups of the participants, involving at most five participant per session. While incorporation of large group of participant allowed improving relevancy of the final model, distribution of them to diverse sessions in the form of sub-groups enabled mitigating with the risk of poor communication and coordination. Risks faced during the GMB sessions are given in Appendix 13.

Involving participants from diverse backgrounds and organizational levels is crucial for the robustness and success of scenario analysis and strategy development. Executives from diverse services and operations such as finance, legal affairs, design, engineering, procurement, insurance, information technologies and human resources made the brainstorming session participative and ensured diversity. In addition, as given in Table 14, Scenario Testing in Session 7 as well as Strategic Options Testing in Session 8 is conducted with a limited number of C-level executives. For example; CEO, CFO, CIO and COO of the Company are participated in Session 7 and CEO in Session 8. Background information of them, their role in the Company as well as their contribution for the Testing Sessions, are explained in Table 63.

In addition, to enhance the success of SD practices undertaken with the Company Experts, pre-meeting trainings are organized by the researcher. As introduced in Chapter 4.2., the concept of SD as well as use of a computerized tool starts with the Session 5. Thus, prior to the Session 5, pre-meeting training sessions are scheduled to introduce the concept of SD. These trainings are provided to each participant separately. Training took 0.5 hours to 1 hour depending on the interest of experts towards SD concept. During the trainings, firstly theoretical background of the systems thinking and dynamics introduced briefly, and then a simplified model, pre-developed in Stella Architecture, is exemplified to managers to introduce the software. Although the concept is still novel to the Company Experts, their feedbacks revealed that, through pre-training sessions the risk of unfamiliarity with the SD concept is highly minimized.

Supporting Tools Techniques: The group modelling process in SD involves cognitive tasks that can be divergent, convergent or evaluative (judgment and choice) [311]. In general, "divergent tasks have to lean on an individual application of techniques or on small nominal groups, convergent and evaluation tasks require plenary sessions, which can be completed by sub-group workshops" [312], [311]. In this regard, various techniques are proposed in current literature to support GMB. Some examples of these techniques are; Delphi method, multi-attribute utility theory, the social judgment analysis, and the nominal group technique [314], simple voting procedures [312], or brainstorming with entire group [313]. In this study, except two session, "brainstorming" is used as a supporting technique for the GMB activities. However, "simple voting procedure" is also facilitated during Session 3 (focus group interviews to select KPIs) as well as during Session 6 (Face Validity Tests to evaluate the validity the final SD model).

Facilitators and Their Roles: [320] and [312] proposes five roles to be characterized within the group modelling team. First is the facilitator, who acts as a group guide and knowledge elicitor. Second is the modeler, or reflector, who focuses on the model that is being formulated by the group and the facilitator. Third as the process coach, who focuses on the dynamics of individuals and subgroups in a team. Forth, the recorder, whose task is to write down or sketch the important elements of the group proceedings. Finally; the gatekeeper, who is usually a person within the "client" group who carries responsibility for the modelling project and initiates it. As suggested by [320] and [311], these roles can either be distributed amongst several participants or combined.

In this study, single facilitator is participated in the sessions with the evidence of facilitator has full knowledge about the scenarios and process itself as well as has a sufficient knowledge of the SD method [321], so that she can manage the sessions. As a single facilitator, she undertakes the traditional roles of "facilitator", "modeler", and "recorder". In this regard, as proposed by [312], she acted as a knowledge elicitor, developed and formulated the model, arranged and guided the sessions. As the facilitators' attitude has a serious impact on the quality of communication and on the establishment of a consensus among participants [322], she put great emphasis on adopting "right" attitudes and skills such as conflict handling, communication, process structuring, neutrality and integrity [321].

Table 12: Design of Group Model Building Sessions

Component	Description
Topics and Targets	
Session Topic	• Brief description of the session topic
Session Type	• Classification of the session type (i.e. workshop, testing or focus group interview session)
Sessions Targets	• Brief description about expectations from the session (i.e. expectations of the Company, researcher, other parties) • Explanation of the expected benefits and findings of the session (i.e. a model, framework developed, an analysis results)
Session Duration	• Average duration allotted to the session
Participant Composition	
Size and Composition	• Number of participants • Organizational roles and levels • Characteristics, attitudes, norm, beliefs, or educational backgrounds of participants
Management Support	• Level of top management support (i.e. directly participation to the sessions)
Pre-Meeting Interviews	• Existence of any pre-meeting interviews scheduled • Existence of any pre-session materials distributed to the participants prior to the sessions
Session Procedure	
Pre-Session Study	• Existence of any preliminary studies conducted by the facilitator prior to the sessions
Session Input	• Input materials utilized during the session
Session Agenda & Methodology	• Agenda of the session, process undertaken during the session • Expectations from the participants throughout the session
Post-Session Study	• Existence of any work expected from the participants to be done after the sessions are conducted
Plenary Sessions	• Brief description of work which is done off site by the facilitator
Session Output	• Brief description of findings of the sessions
Tools and Facilitation Aspects	
Tools and Techniques	• Type and process of modelling • Tools, method or techniques used (i.e. questionnaires/ workbooks) • Existence of any systematic or structured tool is utilized
Facilitators and their roles	• Number of facilitators attending to the sessions, and their roles • Degree of facilitators steers or directs the discussions
Risks & Limitations	• Brief description of risks faced during the sessions
Anonymity & Permissions	• Explanation of whether the names or roles of participants are allowed to be shared with other participants • Explanation of whether the findings of the sessions are permitted to be recorded, shared or re-used

Table 13: Summary of the Structural Dimensions of the GMB Sessions

Session ID	Session Topic	Session Type	Session Duration	Size and composition	Supporting Tools and Techniques
1	Scenario Analysis Workshop	Group Modeling Workshop	5 hours with 1 session break	Top Management: 5 C-level managers	Group Brainstorming
2	Strategy Mapping Workshop	Group Modeling Workshop	3 hours without any break	Top Management: 5 C-level managers	Group Brainstorming, Individual Causal Mapping
3	KPI Selection Interviews	Focus Group Interviews	2 to 4 hour group interviews with 7 different groups	7 focus groups with 2-4 participants attending each. In total 17 participants.	Group Brainstorming, Ranking with 1-5 Likert Scale
4	Scorecard Building Workshop	Group Modeling Workshop	5 hours with 1 session break	Top Management: 5 C-level managers and 4 directors, 9 participants in total	Group Brainstorming, Individual Causal Mapping
5	Model Assumptions Workshop	Group Modeling Workshop	5 hours with 1 session break	Top Management: 5 C-level managers	Group Brainstorming
6	Face Validity Workshop	Group Modeling Workshop	3 hours without any break	Top Management: 5 C-level managers	Group Brainstorming, Stella Architecture (SD tool)
7	Scenario Testing	Testing and Discussion	3 hours without any break	Top Management: 4 C-level managers	Group Brainstorming, Stella Architecture (SD tool)
8	Strategic Options Testing	Testing and Discussion	2 hours without any break	Top Management: Company CEO	Group Brainstorming, Stella Architecture (SD tool)

Table 14: Overview on the Company Experts

Participant Characteristics						Session Participance							
ID	**Age**	**Experience**	**Major**	**Position**	**Level**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	40-45	+ 20 years	Finance	Chief Executive Officer	C-Level							x	x
2	40-45	+ 20 years	Computer Engineer	Chief Information Officer	C-Level	x	x		x	x	x	x	
3	35-40	15-20 years	Finance	Chief Financial Officer	C-Level	x	x		x	x	x	x	
4	40-45	+ 20 years	Civil Engineer	Chief Operations Officer	C-Level	x	x		x	x	x	x	
5	35-40	15-20 years	Law	Chief Legal Officer	C-Level	x	x		x	x	x		
6	35-40	15-20 years	Social Sciences	Chief Human Resources Officer	C-Level	x	x		x	x	x		
7	30-35	10-15 years	Social Sciences	Human Resources Director	Director			x	x				
8	30-35	10-15 years	Finance	Financial Affairs Director	Director			x	x				
9	35-40	15-20 years	Civil Engineer	Procurement Director	Director			x	x				
10	30-35	10-15 years	Civil Engineer	Logistics and Custom Director	Director			x					
11	30-35	10-15 years	Mechanical Engineer	Mechanical Electrical Works Director	Director			x					
12	35-40	15-20 years	Architecture	Architectural Coordination Director	Director			x					
13	35-40	15-20 years	Civil Engineer	HSE Director	Director			x					
14	30-35	10-15 years	Information Technologies	Research and Development Director	Director			x					
15	30-35	10-15 years	Civil Engineer	Portfolio Manager	Manager			x					
16	30-35	10-15 years	Business Administration	Tax Manager	Manager			x					
17	30-35	10-15 years	Business Administration	Administrative Affairs Manager	Manager			x					
18	25-30	5-10 years	Law	Senior Lawyer	Manager			x					
19	25-30	5-10 years	Civil Engineer	Budget and Cost Control Manager	Manager			x					
20	25-30	5-10 years	Civil Engineer	Planning Manager	Manager			x					
21	30-35	10-15 years	Business Administration	Client Relations Manager	Manager			x					
22	30-35	10-15 years	Business Administration	Risk and Internal Control Manager	Manager			x					
23	25-30	5-10 years	Environmental Engineer	HSE Manager	Manager			x					

4.5. THE SOFTWARE ARCHITECTURE

"Modern SD modeling software makes it possible for anyone to participate in the modeling process" [66]. With the use of software, modeling can be done in real-time quickly and interactively with groups. As explained previously, in this research Stella Architecture tool of isee Company is used for SD modeling.

Being founded in 1985 by Barry Richmond, isee Systems is one of the leading developer and manufacturer of Systems Thinking and Dynamic Modeling software [323]. In 1989, the company was awarded the Jay Wright Forrester Award by the System Dynamics Society for being the first to introduce an icon-based model building and simulation tool, Stella. As mentioned by the company, Stella has brought computer simulation-based model building to the mass market. The company introduced a new software, iThink for business simulation in 1990, created the first Management Flight Simulator in 1991, pioneered the introduction of the first Learning Environment in 1995, conducted the first conversational systems thinking workshop in 1999. In 1999, the company also introduced NetSim, a first system to deliver management flight simulators on the web, which has further developed and released new version until 2007. In 2015, the company announced the next generation of Dynamic Modeling software, Stella Professional, which allows real time analytics with Stella Live [323].

Major products of the company dedicated for SD modeling are, Stella Architecture, Stella Designer, and Stella Professional. Stella Professional lets to building and analyzing models. Stella Designer lets to create web interfaces for previously developed models and allows presenting the model locally or published to the web. Stella Architect combines the functionality of Stella Professional and Stella Designer as well as allows editing both the model and interfacing simultaneously. Stella Architect is also known as iThink Version 1.5. There are also other supporting tools for the major products of the company such as; isee Player, isee Exhange and Stella Online. Isee Player is a free software that allows other people to run models created in Stella Professional or Stella Architect. Isee Exchange is a web portal, where modelers can publish interfaces those developed with Stella Designer or Stella Architect. The last, Stella Online, is an online editor that works the same way as modeling works in the desktop product. In this study, Stella Architecture is utilized, which is suitable for both modeling and presentation purposes [323].

Stella Architecture is one of a powerful tool that allows modelers to develop SD models that can be simulated over time. It has a usable interface and provides effective analytics, which enable to advance the developed model quickly. Stella Architecture is selected as a research tool as it provides definitive modeling to create professional simulations and presentations. As given in company website [324], to date, Stella Architecture has been utilized in the fields of Supply Chain Management, Strategic Business Development, Public Policy, Education, Research, Energy, Health, Agriculture, Manufacturing and Conservation. Again as given in company website [324] some features of the Stella Architecture tool are as follows;

- Multimethod Modelling: It integrates SD, discrete events, and some agent-based modelling methods in the same model.
- Model Building: It enables to develop complex models through set of stocks, flows, converters etc.
- Interface Building: It provides design interfaces that provide effective presentation of the model results.
- Storytelling: It enables the communication of the underlying principles of the system developed, through either the whole model or partial model simulation.
- Stella Live Analytics: It dynamically explores policy implementation with instant updating.
- Causal Lens: It quickly traces the causes of a variable's behavior over time.
- Results Explorer: It is easy to analyze the results of each individual variable. It provides both the graphical and tabular simulation results.
- Identify Errors: It quickly finds any errors in equations or units.
- Cycle Time: It precisely computes time of processes and activities.
- Data Manager: It quickly compares data across several runs, archive and recall settings and results.
- Monte Carlo and Sensitivity Analysis: It provides sensitivity analysis to discover key leverage points and find optimal conditions.
- Built-ins: It provides a variety of mathematical, statistical and logical built-ins to develop enhanced equations for variables.
- Multiple Input Control Types: It defines initial/input values also in Interface Window through some set of input control types such as sliders, knobs, switches or numeric.

CHAPTER 5

THE CONCEPTUAL MODEL

This chapter explains the development process of the Conceptual Model. As part of the SPMP, this chapter explains the strategic positioning, strategy formulation and implementation steps undertaken to develop the Conceptual Model. In this regard, the chapter starts with the brief explanation of theoretical base that is utilized when developing PESTBEL-F and RC-F as well as strategic objectives given in the SMS. Based on this base, a set of future probable scenarios are developed to use in Scenario Testing. As part of the "Strategy Formulation" of SPMP, the second section of this chapter explains the methodology about how the strategic objectives for construction companies are extracted and structured as a SMS. Finally, a KPI-F is developed and a BSC Structure is constructed as part of the "Strategy Implementation" of SPMP.

5.1. CONCEPTUAL MODELING PROCESS

A process diagram showing the underlying logic of the Conceptual Model is established to specify requirements of the Model. As depicted in
Figure 5, the diagram of the Conceptual Model is based on the Research Model and IDEF Diagram developed for the SPMP, which are given in Figure 3 and Figure 4, respectively. As explained in Chapter 4, the underlying assumptions of the process can be summarized as follows;

- Opportunities, threats or any other conditions in the global and market environment can be incorporated to the Model in the form of PESTBEL factors.
- Strengths, weaknesses or any other conditions in the corporate and project environment can be incorporated to the Model in the form of Resources and Capabilities (RC) factors. These factors should also constructed in a way that, they can successfully reflect the theories of RBV and Dynamic Capabilities.
- Both the PESTBEL and RC are utilized to define strategic positions of companies.
- Strategic positions of the companies control the way and in what extent their strategies can be implemented.
- Strategies can be implemented through some set of PM methods such as BSC.
- BSC should be developed for both project-level and support services of the companies, especially for the construction industry, which has project- based nature.
- The aggregation of project-based BSC and support services BSC forms the Corporate BSC.
- Strategies can be formulated through defining some set of strategic objectives.

- Strategic positions of companies are also critical for the strategy formulation, as it is necessary to consider characteristics and dynamics of the environment when deciding on the strategies.
- Strategic objectives also need to be translated into some set of performance measures for implementation purposes.
- BSC, in this regard, is one of the most powerful tool to translate the strategy into operational measures.
- After implementation of strategies, companies can improve their existing resources and capabilities, which enhance their strategic capabilities in forthcoming periods.
- Thus, companies should align their strategic positions dynamically, to align them with their improved or released capabilities.

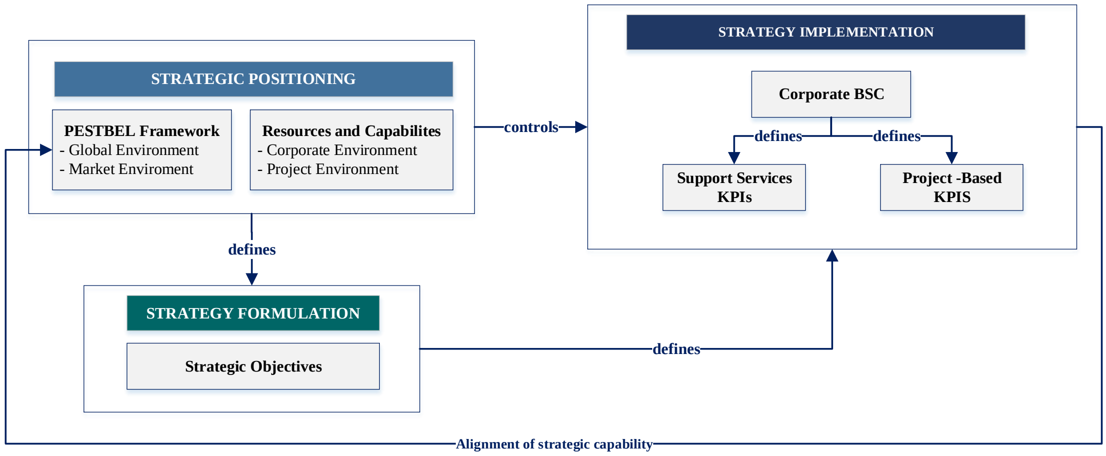


Figure 5: Process Diagram of the Conceptual Model

5.2. STRATEGIC POSITIONING

5.2.1. Theoretical Base

As depicted in Figure 3 and Figure 4, the first step of the SPMP process is “Strategic Positioning”. It refers to the examination and assessment of internal and external environment of the companies under both in current and future conditions. Based on the study of [2], the aim of this step is also to develop future scenarios for construction industry based on future trends and barriers in global and market environment. To do so; a framework containing factors representing internal and external conditions is needed. That framework can be taken as a basis when analyzing the strategic positions of the companies as well as undertaking scenario analysis for future conditions. The called framework was developed in this study as two parts; first a PESTBEL-F and second RC-F. To develop them, a theoretical base is needed to elicit current knowledge about trends, uncertainties, drivers or barriers inherit especially in the external environment.

The theoretical base was developed by searching and identifying studies those focusing on future of the construction industry. To do so; key words containing “construction future”, “construction industry strategy”, “future of construction companies”, “trends and uncertainties of the construction industry” were searched throughout the available literature. The final theoretical base constituted construction future reports, industry reports and reports of excellence initiatives.

The theoretical base was roughly reviewed and classified based on the type of reports such as consultancy reports, reports sponsored by governments, reports published by international alliances/organizations or research institutes. The origin of these reports also captured as they reflect general tendency of the countries about their visions on construction industry. Based on the origins of the reports, the theoretical base was categorized under five groups.

The first group contains publications from diverse institutions or organizations working for the organization team of the European Union (EU), as they are one of the most crucial authorities that set, monitor or shape requirements and standards expected from the industry. The second group consists the publications made by UK, as it is understood from the theoretical base that UK is one of the countries that puts high attention to defining a vision for its construction industry. The third group clusters other European countries into one set, which contains countries such as Ireland, Scotland, Netherlands, Denmark, Finland and Turkey. The publications made by Australia and United States (US) forms the fourth and fifth group, respectively. In addition to the origins of the reports, the theoretical base was also classified based on the publication date and organization responsible from the publication of the report. Detailed information about the theoretical base is given in from Table 15 to Table 18.

To be noted that; the theoretical base was reviewed three times based on three interrelated goals. First review was conducted to extract appropriate factors for PESTBEL-F and RC-F as explained in Chapter 5.2.2. Second review was undertaken to elaborate future trends and opportunities, which were further utilized when developing scenario storylines. The methodology and findings of this step is given in Chapter 5.2.3. A final review was made to develop a generic SOT to the construction industry. The identification of strategic objectives and development of the SMS in accordance, constitute the second step, “Strategy Formulation” of the SPMP. The methodology and findings of this step is given in Chapter 5.3.

Table 15: Number of Publications per Publication Origin

Origin of the Publication	Publication Number
Research/ Institute Report	11
Governmental Departments	10
International Alliances/ Organizations	8
Total	**29**

Table 16: Number of Publications per Leading Country/ Commission

Leading Country/ Commission	Publication Number
UK	8
EU	5
Australia	3
Ireland	3
ILO	2
Finland	1
Denmark	1
Netherlands	1
OECD	1
Scotland	1
Singapore	1
Turkey	1
United States of America	1
Total	**29**

Table 17: Number of Publications per Group

Group	Publication Number
G1: European Union	6
G2: United Kingdom	8
G3: European Countries such as Ireland, Scotland, Netherlands, Denmark	9
G4: Australia	3
G5: United States of America	3
Grand Total	**29**

Table 18: Theoretical Base for Strategic Positioning and Strategy Formulation

Ref	Publication Name	Origin	Leaded By	Group	Responsible	Year	Usage
[325]	Construction 2020: Strategy for the sustainable competitiveness of the construction sector and its enterprises	IA	EU	G1	European Commission	2012	SD
[326]	Europe 2020- A Strategy for smart, sustainable and inclusive growth	IA	EU	G1	European Commission	2010	SD
[327]	A vision for a sustainable and competitive construction sector by 2030	IA	EU	G1	European Commission	2005	SO
[328]	Strategic Research Agenda for the European Construction Sector- Achieving a sustainable and competitive construction sector by 2030	IR	EU	G1	European Commission- European Construction Technology Platform	2005	SO
[329]	The European Construction Sector: A Global Partner	IA	EU	G1	European Commission	2016	SD
[330]	Competition in the Construction Industry	IA	OECD	G1	OECD	2008	SD
[331]	Government Construction Strategy: 2016-20	GD	UK	G2	Infrastructure and Projects Authority	2016	SO
[332]	Construction 2025- Industrial Strategy: Government and Industry in Partnership	GD	UK	G2	HM Government	2013	SO
[333]	Government Construction Strategy: 2011	GD	UK	G2	Cabinet Office- UK	2012	SO
[334]	Modernizing Construction	GD	UK	G2	National Audit Office (NAO)	2001	SD
[335]	Accelerating Change	IR	UK	G2	Strategic Forum for Construction	2014	SO
[336]	Rethinking construction	IR	UK	G2	Construction Task Force	1998	SO
[337]	Foresight futures 2020 Revised Scenarios and Guidance	GD	UK	G2	Department of Trade and Industry (DTI)	2002	SA
[338]	The Professionals Choice: The future of the built environment professionals	IR	UK	G2	Commission for Architecture and the Built Environment	2003	SA

[339]	Construction 2020- A Strategy for a renewed construction sector	GD	Ireland	G3	Stationary Office	2014	SO
[340]	Building our future together	IR	Ireland	G3	Construction Industry Council	2012	SO
[341]	A Strategy for the Construction Industry: Construct 21	IR	Ireland	G3	Master Builders and Contractors Association	n/a	SO
[342]	Boost to the Sector- Evaluation of real estate and construction programmes	IR	Finland	G3	Tekes (the Finnish Funding Agency for Innovation)	2014	SD
[343]	Building for the future- The Scottish Construction Industry’s Strategy	GD	Scotland	G3	Construction Scotland	2012	SO
[344]	Sustainable Competitiveness of the Construction Sector	IR	Netherlands	G3	ECORYS- Research and Consulting	2014	SO
[345]	Future Qualification and Skills needs in the construction sector	IR	Denmark	G3	Danish Technological Institute	2009	SO
[346]	Onuncu Kalkınma Planı: 2014-2018	GD	Turkey	G3	T.C Kalkınma Bakanlığı	2013	SD
[347]	Sectoral Innovation Foresight- Construction	IR	Australia	G3	Europe Innova	2009	SO
[348]	Construction 2020- A Vision for Australia's Property and Construction Industry	IR	Australia	G4	Cooperative Research Centre (CRC) for Construction Innovation	2004	SO
[349]	Industry culture: a need for change	IA	Australia	G4	The Australian Cooperative Research Centre for Construction Innovation	2001	SD
[350]	Construction 21. Re-inventing construction. June 1999	GD	Singapore	G4	Ministry of Manpower and Ministry of National Development	1999	SD
[351]	National Construction Agenda: For Occupational Safety And Health Research And Practice In The U.S. Construction Sector	GD	United States of America	G5	NORA Construction Sector Council	2008	SD
[352]	The construction industry in the twenty- first century: its image, employment, prospects & skills requirements	IA	ILO	G5	International Labor Organization	2001	SD

[353]	Good Practices and challenges in promoting decent work in construction and infrastructure projects	IA	ILO	G5	International Labor Organization	2015	SD

IA: International Alliances/ Organizations, GD: Governmental Departments, IR: Institute/ Research Report
SA: Scenario Analysis, SO: Strategic Objective, SD: Supporting Document

5.2.2. PESTBEL and RC Framework

The strategic position structure of this research is based on the work of [77] and [78], which studies RBV in strategic analysis. As depicted in Figure 6, the structure incorporates the theories of “RBV”, “Market-Based View” and “Competitive Advantage”. It suggests internal environment of the companies can be analyzed via “RBV”, while in the analysis of external environment “Market-Based View” can be taken as a basis. The structure also proposes that, both analysis can be undertaken in the form of “SWOT” analysis.

SWOT analysis is one the highly utilized tool in strategic management by providing simple situation analysis. It is based on RC as well as factors of business environment, whose combination provides a slightly modified SM, making SM as a component of the meta- SWOT tool ([354], [355]). It is formed from strength and weaknesses dimensions representing the internal capabilities of organizations as well as opportunities and threats reflecting the conditions in the external environment. In this study, both the PESTBEL-F and RC-F were utilized as components of a SWOT, to represent the internal and external conditions of the organizations. The dimensions of opportunities and threats representing external conditions were used when developing PESTBEL-F, which was further facilitated for scenario analysis purposes. In addition, the dimensions of strengths and weaknesses showing internal conditions were utilized when developing RC-F, which were further facilitated for SD purposes. As explained in Chapter 8, the SD models are composed of “Stock Flow Diagrams” utilized for quantification and simulation of accumulation of RC of organizations.

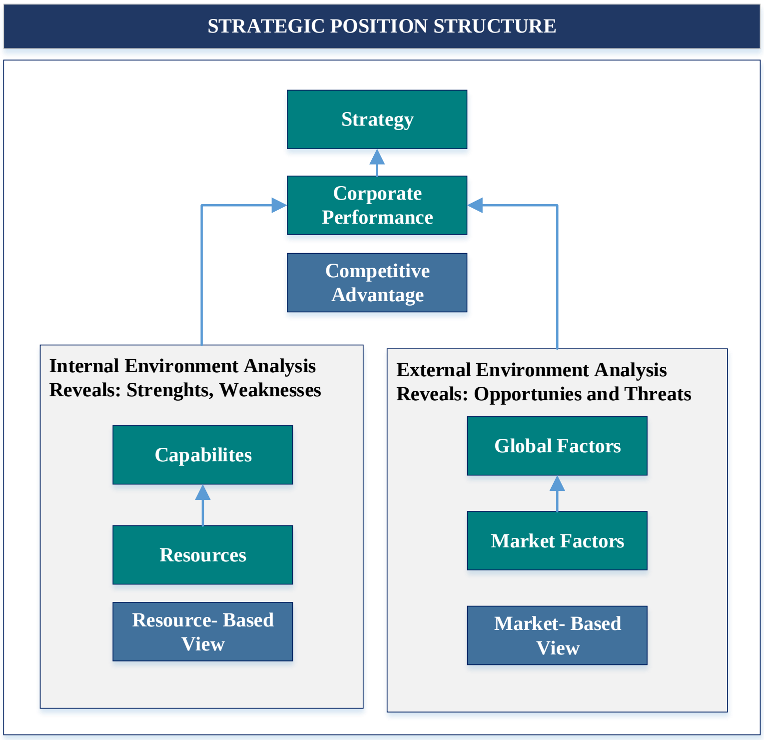


Figure 6: Strategic Position Structure

As explained in previous section, the theoretical base was firstly utilized to develop a PESTBEL-F. Originally, PESTEL is account for Political, Economic, Social, Technological, Environmental and Legal factors surrounding organizational systems. PESTEL technique is useful for both scenario analysis [356] and situation analysis of the external environment. In line with the various scholars (i.e. [50], [356]) PESTEL factors together with organizational conditions were utilized to create future scenarios which were further used to simulate SM under diverse scenarios.

Based on the content analysis on the theoretical base, PESTBEL-F was developed by also making two modifications on the original PESTEL framework. These modifications are as follows;

1) The original framework was divided into global and market levels to make the distinction between the global and market conditions. Global conditions are the ones that have potential to effect whole industries including the construction industry, whereas market conditions are the ones that may directly influence the industry. In traditional applications of PESTEL technique, distinction between the levels (i.e. global or market) among its dimensions are limited.

2) The original framework consists of six dimensions whose initials form the abbreviation of "PESTEL". These dimensions are; political, economic, social, technological, environmental and legal. In addition to these dimensions, a new dimension named "Business" was added to reflect business conditions influencing organizations. Similar to the other dimensions, the business dimension was also elaborated from two levels, global and market. Thus, as an additional acronym "B" was added to reflect Business dimension to the original framework, forming "PESTBEL" specific to this research.

Thus, the modified framework consists of two attributes; dimensions representing the contextual characteristics of external conditions, and levels representing the degree and comprehensiveness of these conditions effecting the external environment. Based on these attributes; the modified framework is composed of;

1) **Dimensions:** Dimensions including Political, Economic, Social, Technological, Business, Environmental, and Legal,
2) **Levels**: Levels including Global and Market.

The combination of PESTBEL and SWOT techniques required a systematic and iterative process of "Future Thinking" theory of [2]. To do so; firstly, factors defined in PESTBEL-F were listed along with their dimensions and levels. Second; probable future opportunities and threats, representing SWOT framework, were identified for each PESTBEL factor separately. As a further effort, these future opportunities and threats were further merged to write probable scenario storylines.

Scenario storylines reflect the textural statements of external conditions that have probability to occur in future those can be either opportunity or threat. In order to develop scenario storylines, firstly a matrix was formed by reviewing, selecting and combining the statements of "opportunities" and "threats" given in PESTBEL- SWOT framework, which was further named as "PESTBEL Opportunity & Threat Matrix for Scenario Storylines". The matrix was structured in way that; textural statements of future conditions given in the matrix were written in terms of a) their PESTBEL level (global and market), b) their PESTBEL dimension (political, economic, social, technological, business, environment and legal), c) its SWOT dimension (opportunities and threats). Both the "PESTBEL- SWOT Framework" and "Scenario Storylines" were utilized when producing scenarios and selecting scenario scenes in the context of Session 1. Both the framework and scenario storylines are also given in Appendix 2.

In addition to the PESTBEL-F, a RC-F was developed to define conditions of the internal environment of the Company. Similar to the PESTBEL, the dimensions of RC-F can further be utilized to reflect strengths and weaknesses of organizations analyzed in SWOT technique.

RC-F was developed by using the theoretical base and available literature on RBV. As given in Chapter 2, typologies for organizational resources proposed by [77] and [78] were utilized to classify the resources given in RC-F. Internal factors identified in the [357] were used to define the factors of RC-F. [357] explored internal and external environmental factors, those named as "enterprise environmental factors" that have potential to influence a project's success. It listed some internal environment factors as; organizational culture, structure, and processes (i.e. design, development, law, contracting, and purchasing), human capital (i.e. skills, knowledge), and personnel administration (i.e. staffing and retention guidelines, employee performance reviews and training records, overtime policy, and time tracking).

Similar to the PESTBEL-F, the RC-F also consists two attributes; dimensions representing the contextual characteristics of internal conditions, and levels representing the degree and comprehensiveness of these conditions effecting the internal environment. Based on these attributes; the RC-F is composed of;

1) **Dimensions:** Dimensions including 1) Stakeholders, 2) Financial Resources, 3) Governance and Compliance Capabilities, 4) Technology and Human Capital, 5) Construction Resources, 6) Sustainability Capabilities, 7) Management Capabilities
2) **Levels**: Levels including Corporate and Project.

The final PESTBEL-F and RC-F are given in Table 19 and Table 20, respectively. Internal factors from RC-F and external factors from PESTBEL-F were further utilized to reflect strategic position of the Company. The factors specific to the Company and its market, were selected by the Company Experts in Session 4 in order to customize these generic frameworks to the Company. The Company-specific factors were further combined with KPIs in the BSC Structure, their causal linkages with KPIs and other factors were developed in Conceptual Map, as well as they were developed in Computerized Map to add the Model dynamic nature. In this regard; internal factors from RC-F are critical as they form the basis for resource accumulations and disposals.

External factors from PESTBEL-F, are however, form the basis for scenario-based simulations.

The theoretical background about RBV and Dynamic Capabilities are given in Chapter 2. Chapter 6 also describes how dynamic capabilities are formulated and tested in the scope of this study. However, both the theoretical background of scenario analysis as well as its application in this research, are given in forthcoming section, Chapter 5.2.4.

Table 19: PESTBEL Framework

PESTBEL FRAMEWORK							
	Political	**Economic**	**Social**	**Technological**	**Business**	**Environment**	**Legal**
Global	PO-1: Effectiveness of political system & development PO-2: Level of political stability PO-3: Level of threats for national security PO-4: Level of international relations	EC-1: Economic development & growth EC-2: Government budget deficit / country debt EC-3: Level of globalization EC-4: Income and employment	SO-1: Social equality & ethics SO-2: Social crisis SO-3: Population demographics SO-4: Social maturity	TE-1: Power of technology TE-2: Investment in R&D and innovation	BU-1: Market size and growth BU-2: New countries and markets	EN-1: Environmental awareness / protection regulations EN-2: Environmental pollution EN-3: Energy & water scarcity EN-4: Ecological balance & preservation EN-5: Level of climate change	LE-1: Regulatory bodies and processes LE-2: Maturity of legal system LE-3: Compliance with international laws, rules, standards
Market	PO-5: Degree of government intervention in business PO-6: Level of international trade and foreign investments	EC-5: Market economic structure & strenght EC-6: Market availability of financial resources EC-7: Regulations specific to construction	SO-5: Industry image SO-6: Employment patterns	TE-3: Industry R&D and innovation potential TE-4: Technological trends	BU-3: Market trend & maturity BU-4: Power of suppliers and vendors BU-5: Power of competitors BU-6: Barriers to entry BU-7: Barriers to exit BU-8: Client requirements & maturity BU-9: Market availability of construction resources	EN-6: Market environmental regulations EN-7: Market advancements in environment	LE-4: Industry regulations about construction LE-5: Claim and litigation system

Table 20: Resources and Capabilities Framework

RESOURCES CAPABILITIES FRAMEWORK							
	Stakeholders	**Financial Resources**	**Governance & Compliance Capabilities**	**Technology and Human Capital**	**Construction Resources**	**Sustainability Capabilities**	**Management Capabilities**
Corporate	ST-1: Relations with Public ST-2: Relations with Creditors ST-3: Relations with Regulatory Bodies	FI-1: Insurance Resources FI-2: 'Corporate Financial Statements	GC-3: Corporate Governance Capabilities GC-4: Legal Affairs Management	TE-1: Innovation and R&D Capability TE-2: Technological Capability TE-3: Organizational Capital		SU-3: Corporate Social Responsibility	
Project	ST-4: Relations with Clients ST-5: Relations with Partners ST-6: Relations with Subcontractors/Suppliers ST-7: Relations with Designer/Engineers	FI-3: Project Financing Capabilities FI-4: Project Financial Statements	GC-1: Contract Management Capabilities GC-2: Risk Management Capabilities	TE-4: Knowledge Management Capabilities TE-5: Human Capital	CR-1: Labor Resources CR-2: Material Resources CR-3: Equipment Resources CR-4: Infrastructure Resources	SU-1: Environmental Management SU-2: Health and Safety Management	MN-1: Cost Management Capabilities MN-2: Time Management Capabilities MN-3: Scope Management Capabilities MN-4: Quality Management Capabilities MN-5: Procurement Management Capabilities

5.2.3. Scenario Analysis Process

Scenarios are the storylines that include a range of interdependent and uncertain future events and their probable consequences [61]. They are internally consistent view of what the future might turn out to be - not a forecast, but one possible future outcome [94]. They enable organizations to handle growing uncertainties by acquiring multiple views of the future that describe a range of opportunities [2].

Scenario analysis/ planning (SA) is a qualitative and systematic way to depict possible future states [56]. It has become popular in the 1970s as a tool to advice organizations by distilling the countless possibilities of the future state into a limited set of coherent views [2]. Using scenario analysis, probable storylines can be developed based on current trends ad future conditions evolving in organization's external environment [60].

In this research, Scenario Analysis is elaborated as the first step for the SPMP, with which strategic positions of the companies can be structured for both present and future state. It also reflects the dynamic nature of the SMs of organizations, which may change, based on the changes in their external environment. As a first step of SPMP, a separate process named, Scenario Analysis Process (SAP), was also defined based on the scenario analysis methodologies proposed by [356], [358] and [359]. The proposed methodologies were combined and modified in line with the necessities of the Company. The overview of the SAP along its theoretical basis is summarized in Table 21.

To be noted that, SAP was conducted in Session 1 in the form of a real-time scenario analysis practice, which was held with Company Experts. Thus, scenarios were not tested via any technique (i.e. cross-impact analysis of [356]). However, probable implications of these scenarios were iteratively tested throughout Session 1, as the strategies were firstly elaborated via brainstorming and further developed by using SOT in Session 2. The detailed background of Session 1 is given in Table 22.

Table 21: Scenario Analysis Process

Scenario Analysis Process	Context of the Process	Theoretical Basis
1) Developing PESTBEL Framework	• Generating and selecting scenario factors those represent future external environment • The factors reflect probable drivers, trends and uncertainties in the future	• Step 2 - [356] • Step 1 - [358] • Step 3 - [359]
2) Conducting Initial Scenario Assessment	• Clustering the scenario drivers (named as PESTBEL dimensions) • Refining number of scenarios by eliminating the duplicate or least probable scenarios via mental models of the Company experts	• n/a
3) Conducting Secondary	• Ranking the PESTBEL dimensions in terms of "Probability of Occurrence" and	• Step 2 - [358] • Step 4 - [359]

Scenario Assessment	“Potential Undesirable Impact” the Company • Developing a Scenario Assessment Matrix for the visualization purposes	
4) Conducting Final Scenario Assessment	• Choosing 3 scenarios those reflect the highest, middle and lowest level of ranks in terms of probability of occurrence and potential impact	• Step 3 - [356] • Step 3 - [358] • Step 5 - [359]
5) Conducting Scenario Formulation	• Choosing scenario storylines in global, market and company level for each scenario from “PESTBEL Opportunity & Threat Matrix for Scenario Storylines”	• Step 4 - [358] • Step 6 - [359]
6) Identifying Scenario-Based Strategic Objectives	• Develop strategic objectives that would be robust under each scenario	• Step 5 - [356] • Step 7 - [359]

SAP was carried out with one-off workshop session, Session 1, via pre-prepared PESTBEL-F and scenario storylines, which were sent to the Company Experts one week prior to the session day via e-mail. The session was started with the presentation of PESTBEL-F and discussion of the probable scenario storylines by the Company Experts.

Scenario drivers, reflecting the probable trends, drivers and uncertainties in the future, were generated and selected based on the PESTBEL-F. The framework was given in a way that, it reflected the factors associated with political, economic, social, technological, business, environment and legal environments. As described in Chapter 5.2.2, scenario storylines for each PESTBEL dimension was also provided to the Company Experts in Session 1.

SAP 1. Developing SAP Materials: It is common in literature (i.e. [55], [63]) to create four scenarios by utilizing a grid of two dimensions, each describing opposite sides of a trend or uncertainty, combination of which lead to four diverse scenarios. To make the exercise more practical, some other authors such as [57] and [50] recommended development of two or three scenarios; one for extrapolation of the present, a second one for bright- prepared future, and third scenario representing gloomy or undesirable future. In this study, after several assessment, three scenarios were selected at last, for the three purposes suggested in [50].

As the scenarios are produced by utilizing a grid of n number of dimensions, each describing opposite sides of opportunities and threat, combination of which lead to 2^n diverse scenarios. The original PESTBEL-F consists of seven dimensions, which concurrently leads to 2^7 number of dimensions. As the assessment of such a number of scenarios is neither practical nor simple, the dimensions were clustered and refined to decrease “n” in 2^n number of scenarios. To do so; as they have similar contexts and have diverse interrelations; political, economic and social dimensions were clustered forming a single scenario driver. In addition, social and environmental dimensions were grouped as they both reflect different fields of sustainability. Technological and business dimensions were remained as original without combining with any other dimension. The modified framework formed up with 4 dimensions, which in turn lead to 2^4, that's 16 diverse scenarios.

SAP 2. Conducting Initial Assessment: In the initial assessment, it was expected from Company Experts to refine 16 scenarios to eight scenarios by eliminating least probable scenarios. Both the framework and textural statements/assessments of Company experts are given in Appendix 3.

SAP 3. Conducting Secondary Assessment: In the context of secondary scenario assessment, the selected eight scenarios in the first assessment were evaluated in detail by the Company experts. To do so; the PESTBEL dimensions of each scenario were ranked in terms of their "Probability of Occurrence" and "Potential Undesirable Impact to the Company" in 1-5 Likert scale. While "Probability of Occurrence" reflects the externality of the scenarios, "Potential Undesirable Impact to the Company" represents how opportunities and threats in external environment can influence the organization. The rankings of each were multiplied to calculate the overall "Rating" of the scenario. The ratings were grouped into three classes;

- A Level Scenarios those have rating equal to or higher than 12,
- B Level Scenarios those have rating higher than 7 but less than 12,
- C Level Scenarios those have rating equal to or less than 7.

The rated eight scenarios were further constructed into a Scenario Assessment Matrix for visualization purposes. The Matrix was in the form of "likelihood" in y axis and "impact" in x axis. The matrix was further utilized in final scenario assessment as a decision-support tool for Company Experts. The scenario assessment log and matrix are given in Appendix 3.

SAP 4. Conducting Final Scenario Assessment: Three scenarios were selected from the eight scenarios rated in the previous step via also utilizing "Scenario Assessment Matrix". These three scenarios were chosen those reflect the highest, middle and lowest level of ratings in terms of probability of occurrence and potential impact. The underlying theory of selecting the scenarios based on highest, middle and lowest level of ratings is to ensure diversity of probable future states and comprehend different levels of occurrences and impacts of scenario drivers. The final scenario assessment log is given in Appendix 3.

SAP 5. Conducting Scenario Formulation: After three scenarios were selected by the Company Experts, scenario storylines were defined in global, market and company level for each scenario. The storylines were selected from "PESTBEL Opportunity & Threat Matrix for Scenario Storylines" developed in the Chapter 5.2.2. The final Scenario Formulation Matrix is given in Table 23.

SAP 6. Identifying Strategic Objectives: The Scenario Analysis Workshop, Session 1, has also formed a basis for strategic decision making which further utilized when defining of strategic objectives in Strategy Mapping Workshop, Session 2. The outcome of Session 1 contains the knowledge and experience of experts gained from their knowledge and experience as well as their judgement about future. Thus, the final step of scenario analysis is also the first step of the strategy mapping process. In the context of this step, strategic objectives were developed that are expected to be robust under each scenario and generic throughout the industry.

Table 22: Scenario Analysis Workshop

Session 1: Scenario Analysis Workshop	
General Information	
Session Topic	Scenario Analysis Workshop
Session Type	Group Modeling Workshop
Session Targets	• Validation of PESTBEL Opportunity & Threat Matrix for Scenario Storylines • Development of three future scenarios for construction industry
Session Duration	5 hours with 1 session break
Participant Composition	
Size and composition	Top Management: 5 C-level managers
Management Support	Direct support: Workshop attendance and open conversation
Pre-Meeting Interviews	Pre-meeting interviews were not scheduled. However, pre-session materials (i.e. PESTBEL-F, PESTBEL Opportunity/ Threat Indicators, PESTBEL Opportunity & Threat Matrix for Scenario Storylines) were distributed to the participants one week before the workshop day.
Session Procedure	
Pre-Session Study	• Identifying initial requirements of the Company • Identify key factors by interviewing people within the organization • Developing PESTBEL Framework
Session Input	• PESTBEL-F and RC-F • PESTBEL and RC SWOT Indicators • PESTBEL for Scenario Storylines
Session Agenda & Methodology	• Overview and validation of input materials • Conducting Initial Scenario Assessment: Elimination of eight scenarios directly, which are decided as having no reliability in context, by using Initial Scenario Assessment Log • Conducting Secondary Scenario Assessment: Assessment of remaining eight scenarios in terms of probability of occurrence and potential impact using Secondary Scenario Assessment Log • Conducting Final Scenario Assessment: Selection of three scenarios, which represent highest, medium and lowest level of Rating, by using Final Scenario Assessment Log and Scenario Assessment Matrix • Conducting Scenario Formulation: Development of Scenario Formulation Matrix by defining scenario storylines for each scenario by using PESTBEL Opportunity & Threat Matrix for Scenario Storylines
Post-Session Study	• Rewriting and finalizing PESTBEL Opportunity & Threat Matrix for Scenario Storylines

	• Finalizing Scenario Assessment Log, Scenario Assessment Matrix and Scenario Formulation Matrix
Plenary Sessions	Verbal statements were recorded to maintain opinions of Company Experts. These statements were further converted and given in Initial Scenario Assessment Log. The statements were also sent to Company Experts for validation purposes.
Session Output	• Scenario Formulation Matrix
Methodology, Tools and Facilitation Aspects	
Tools and Techniques	Group Brainstorming
Facilitators and their roles	Researcher was the facilitator. She opened dialogues, directed the session and interactively reflected the opinions of participants on the templates created in MS Office-Excel. Researcher did not add or reject any opinion proposed by participants.
Risks & Limitations	**Risk 1.** Difficulties in achieving a consensus on three scenarios **Risk 2.** Reliance on judgements and opinions of dominant participant **Risk 3.** Excessive time to get participants used to and familiarize with future thinking (as claimed in the report of [63] **Risk 4.** Concerns of participants to share their opinion with others **Risk 5.** Difficulty in developing a shared understanding of future thinking due to individual biases
Anonymity & Permissions	Participants' names, ideas and choices could be seen and shared by others. Participants could not reject or remove ideas of other participants. The company allowed publishing assessment and formulation results.

Pre-Session Study: Work done off site by researcher, **Session Agenda & Methodology:** Work done with the group in the session, **Post-Session Study:** Work done off site by researcher, **Plenary Sessions:** Work done with the group

Table 23: Scenario Formulation Matrix

Scenario Name	Scenario Storyline- Global	Scenario Storyline- Market	Strategy Provision- Company
Scenario 1: Mature and all in pocket	**Political** 1. Stable political conditions 2. Stronger and stable international relations **Economic** 3. Stable/ healthy economic indicators (i.e. inflation, interest and exchange rate) 4. Foreign economic investments 5. Increased financial strength with international partnerships 6. Low unemployment **Social** 7. Sustained social peace **Technological** 8. Increased power of technology 9. High level of investment in R&D **Environmental** 10. Climate change is under control 11. Whole triple bottom line & sustainability culture **Legal** 12. Effective regulatory bodies & processes 13. Mature/ stable country laws and regulations **Business** 14. Increased globalization 15. Market confidence in new business segments	**Political** 1. Governments promote business development 2. Increased globalization of the industry **Economic** 3. Credit/ cash availability from internal creditors/ banks/ sponsors 4. High profit margin **Social** 5. Better reputation of the industry 6. No discrimination in employment **Technological** 7. Clients require novel techniques in projects 8. Digitization & automation in construction 9. High level of ICT, BIM, virtual spaces, 3D object-oriented modelling and GIS use **Environmental** 10. Self-sufficient zero-energy or even plus-energy communities, solutions 11. Increased attention to sustainability has already solved the energy, climate, water, pollution related risks **Legal** 12. Mature/ stable construction laws and regulations (i.e. tax, labor, employment, health and safety, export and import policies) 13. Effective management of claims, disputes, disagreements, conflicts and contract related problems **Business** 14. Partnering, JV and framework agreements 15. Strategic long-term shareholders 16. Increased work skills and industrial capacity	1. Specific focus on improving sustainability, technology and human growth, corporate governance as advancements are growing 2. Focus in on both existing clients and looking forward to new investments, mergers and acquisitions (MA) 3. Major aim is to diversify, open up to new markets and investments 4. Aim to have /or already have a centrally structured and mature a Holding company to satisfy corporate issues (i.e. advanced strategic and governance issues)

Scenario Name	Scenario Storyline- Global	Scenario Storyline- Market	Strategy Provision- Company
Scenario 7: Sensitive future thinker	**Political** 1. Stable political conditions 2. Stronger and stable international relations **Economic** 3. Stable/ healthy economic indicators (i.e. inflation, interest and exchange rate) 4. Foreign economic investments 5. Increased financial strength with international partnerships 6. Low unemployment **Social** 7. Increasing social polarization 8. Aging population **Technological** 9. Little requirements about technology 10. No investment in R&D **Environment** 11. Increased energy scarcity and water crisis 12. Increasing climate change not controlled **Legal** 12. Effective regulatory bodies & processes 13. Mature/ stable country laws and regulations **Business** 14. Slow industry growth 15. Improvement in construction is seen as expensive	**Political** 1. Governments promote business development 2. Increased globalization of the industry **Economic** 3. Credit/ cash availability from internal creditors/ banks/ sponsors 4. High profit margin **Social** 5. Poor image of the industry 6. Labor market discrimination **Technological** 7. No novel technological advancement 8. Low innovation potential **Environment** 9. Climate change demands new types of construction 10. Pollution levels/ climate change demand extensive regulation of the industry **Legal** 12. Mature/ stable construction laws and regulations (i.e. tax, labor/ employment, health& safety, export and import policies) 13. Effective management of claims, disputes, disagreements, conflicts and contract related problems **Business** 14. Projects are still unpredictable in terms of cost, time and quality 15. Aged skilled workforce, skill shortage	1. Specific focus on sustainability, technology and human growth as they are a threat 2. Focus is primarily on existing clients but also looking forward to new investments, mergers, acquisitions 3. Major aim is to diversify, open up to new markets and investments while environment and technology are the major limitations

Scenario Name	Scenario Storyline- Global	Scenario Storyline- Market	Strategy Provision- Company
Scenario 16: Maintain and Survive	**Political** 1. Instable & vulnerable government 2. Sanctions from other countries 3. Poor relations in international alliances **Economic** 4. Vulnerable and instable economic indicators 5. No foreign investment 6. Debt crisis, currency collapse, money volatile **Social** 7. High level of nationwide strikes, civil wars, riots, protest and demonstrations 8. Increasing social polarization **Technological** 9. Little requirements about technology 10. No investment in R&D **Environment** 11. No specific law / regulations to protect environment 12. Increased energy scarcity and water crisis 13. Increasing climate change, not controlled **Legal** 14. Vague and complex laws and regulations 15. Existence of corruption, bribes **Business** 16. New business segments are too risky 17. Business that is unpredictable, competitive only on price not quality	**Political** 1. Government regulations too strict and complex to do business 2. High level of bureaucracy **Economic** 3. Expenses are vulnerable and volatile to price changes 4. No access to finance 5. Government funds are not available **Social** 6. Poor image of the industry 7. Labor market discrimination **Technological** 8. Clients focus in on cost 9. Reliance on traditional materials and methods **Environment** 10. Pollution levels/ climate change demand extensive regulation of the industry 11. No considerable technological advancements to mitigate with climate change and resource scarcity **Legal** 12. Poor management of claims, disputes, disagreements, conflicts and contract related problems 13. Vague and complex construction laws and regulations (i.e. tax, fiscal, monetary, industrial, labor/ employment, health& safety, export and import policies) **Business** 14. Projects are based on lowest cost 15. No strategic partnerships 16. Traditional contract-based procurement and project management	1. No aim for diversification, internalization and new investment 2. Focus is on maintaining current clients and continues the way business has been done previously 3. No specific focus on sustainability, technology and human growth, the major focus in on finding and maintaining financial resources 4. The industry has been forced to concentrate more on survival than on investing for the future 5. Government funds or credits from banks are not available, companies that are mature and have financial strength will survive

5.3. STRATEGY FORMULATION

5.3.1. Strategic Objectives Taxonomy

Strategic Objectives Taxonomy (SOT) was developed by conducting a structured content analysis on the theoretical base about construction future literature given in Chapter 5.2.1. During the content analysis, a similar methodology undertaken by [360] is conducted. The steps of the content analysis are; 1) conducting initial content analysis, 2) identifying strategic themes, 3) developing SOT.

1. **Conducting Initial Content Analysis:** Reports included in theoretical base were reviewed in detail by the researcher. During the reading session, the researcher took notes about the context of the studies, which were further utilized as a reminding tool, as the base includes excessive amount of information about strategies in construction. Based on the notes taken by the researcher; the whole research base reviewed rather than a secondary reading. During this review, the statements about the vision, strategy, goal or strategic objectives towards future of construction industry, were captured and extracted. The original statements of strategic objectives, extracted from the research base, are given in Appendix 4.

2. **Identifying Strategic Themes:** Strategic themes represent the combination of strategic objectives having contextual similarities. The concept of "strategic theme" is based on the original BSC theory of Kaplan and Norton. In their publication in 2006 [170], authors defined the strategic themes as groups together which clusters "different corporate-level objectives, measures and initiatives across the various perspectives of the BSC framework. In this study, strategic objectives found in previous steps were clustered under five themes; 1) human and social capital, 2) innovation and technology capital, 3) sustainability, 4) business opportunities and competitiveness, and 5) operational and regulatory excellence. With re-wording the statements given in theoretical base, 14 sub-themes associated with the five strategic theme and 109 strategies associated with the 14 sub-themes were defined. These 109 strategies along with the strategic themes are given in Table 72, in Appendix 4.

3. **Developing Strategic Objectives Taxonomy:** As a further approach, strategic objectives utilized in this study, were explored by undertaking a secondary clustering approach. To do so, strategies given in Table 72 were clustered around 28 strategic objectives for international construction companies, which form Strategic Objectives Taxonomy (SOT) given in Table 24. To be highlighted, some strategic objectives given in this taxonomy were explored when conducting Session 1. For example; neither government-based reports nor excellence initiatives has directly focused on "Maximizing Shareholder Value". However; as also mentioned by the Company Rxperts, one of ultimate aims of the private companies is to maximize revenue and profitability, which in turn maximize the value provided to their shareholders. Thus, SOT given in Table 24 was further utilized in developing SM and BSC structure as is explained in the forthcoming chapters.

Table 24: Strategic Objectives Taxonomy

BSC Perspective	ID	Strategic Objectives
P1: Financial Perspective	SO1	Maximize Shareholder Value
	SO2	Maximize Profitability
	SO3	Improve Revenue Growth
	SO4	Improve Cash Flow Strength
	SO5	Improve Investment Return
	SO6	Improve Balance Sheet Performance
P2: Market & Business Growth Perspective	SO7	Improve Market Share and Competitiveness
	SO8	Improve Strategic Initiatives (partnerships, MA)
	SO9	Improve Internationalization
P3: Stakeholder Perspective	SO10	Improve Client Satisfaction & Loyalty
	SO11	Improve Reputation & Brand Recognition
	SO12	Improve Creditor and Financial Resource Availability
P4: Project Management Perspective	SO13	Improve Cost Management Performance
	SO14	Improve Time Management Performance
	SO15	Improve Quality Management Performance
	SO16	Improve Project Management Skills (Scope, Integration, Communication)
	SO17	Improve Supply Chain Management Performance
	SO18	Improve Site Management Performance
	SO19	Improve Design and Engineering Performance
P5: Governance and Compliance Perspective	SO20	Improve Contract Management Performance
	SO21	Improve Regulatory Compliance
	SO22	Improve Risk Management Performance
P6: Sustainability Perspective	SO23	Improve Environmental Performance
	SO24	Improve Health and Safety Performance
	SO25	Improve Social Performance
P7: Learning and Growth Perspective	SO26	Improve Human Capital Capability
	SO27	Improve Technology & Innovation Capability
	SO28	Improve Knowledge & Intellectual Capital

5.3.2. Strategy Map Structure

Deciding on the performance measures is a process starting firstly with the defining the organizations' business strategy and objectives followed with the translating those strategies and objectives into divisional and individual goals [137]. In this regard, the perspectives of the SM have evolved through the exploration of the strategic objectives, as given in Chapter 5.3.1. To do so; first a preliminary SM was developed by the researcher based on the SOT given in Table 24. Some set of strategic objectives were selected by the researcher from SOT as well as categorized based on their contextual background gained from theoretical base.

In this regard, selected strategic objectives were grouped under seven perspectives namely; 1) Financial, 2) Market and Business Growth, 3) Stakeholder, 4) Project Management, 5) Governance and Compliance, 6) Sustainability, 7) Learning and

Growth. The theoretical background of each perspective is given in following sections. In addition, the final SMS is given in
Figure **7**. In a similar manner to the underlying premise of the original SM of Kaplan and Norton, the idea of SM proposed in this study infers;

- Learning and growth perspective contribute to the improvement of sustainability practices, ensuring corporate governance requirements and internal efficiency of construction process,
- Which in turn benefits the firm in obtaining outstanding project management performance as well as satisfying customers and other stakeholders,
- Consequently, satisfied customers and stakeholders, complied laws, regulations and standards and collaborated creditors and sponsors result in a higher market performance, improve competitiveness both in national and international construction market as well as satisfying requirements for entering into new markets, regions
- So that the firm can secure and enhance its revenue growth, profitability, investment success needed to maximize shareholders value.
- The outcomes of each perspective are accumulated to derive overall performance of the organizations.

After the preliminary SM was developed by the researcher, Session 2 was conducted with the Company Experts to validate and finalize the map. To do so; Session 2 was started with a presentation of SOT and discussion of the validity of these objectives by the Company Experts. The SOT as well as Scenario Formulation Matrix were also sent to Company Experts one week prior to the workshop day via e-mail. During the examination of SOT, it was expected from the Company Experts to discuss strategic objectives given in SOT and define probable strategic objectives given in SOT under three scenarios defined in Strategy Formulation Matrix.

As the second step, similar to the methodology undertaken by [71] was followed. In this context, firstly it was expected from the Company Experts to conduct individual causal mapping practices in order to define possible interconnections among strategic objectives based on their own experience and judgement. These practices are important as they reflect the individual mental models of the experts as well as enable to capture how the initial individual mental models are diversified after the group modelling. These practices also enabled experts to get familiarize with the causal mapping exercise so that; they get more experience before the final group mapping practice, undertaken again in the same session. This also improved the accuracy and productivity of the GMB.

As a third step, the findings of the preparatory maps, which were developed by the experts individually, were discussed in Session 2. In this context, each expert introduced and described their own causal maps to other experts, which further engaged the group in an open discussion about individual causal maps. The verbal statements of experts during the discussions were captured and maintained by the researcher in order to utilize them when finalizing the SMS after Session 2.

After the discussion, the preliminary SMS was introduced and explained to experts by the researcher in order to identify the gaps among preliminary SMS developed by the researcher and individual maps developed by the Company Experts. In this regard, each dependency chain inherit in the SMS is explained in detail and experts were encouraged to discuss these causalities among strategies objectives. Based on the discussions of the experts, some additional chains were formed as well as some of them were deleted. An example from the verbal statements of the Company Experts is given as follow;

- "An advancement in technology and innovation can directly form a new kind of financial gain. For example; with an innovation in our IT systems, we can reduce idle IT costs, which in turn decrease administrative costs and increase overall profitability of the organization. Thus, there shall be a direct bi-directional causality among "Learning and Growth Perspective" and "Financial Perspective". Based on the discussion, a new bi-directional chain was added to SMS that links "Learning and Growth Perspective" with the "Financial Perspective".

The findings of Session 2 contain the knowledge and experience of experts gained from their previous practical and theoretical knowledge. The findings were also highly associated with the cognitive abilities of Company Experts in strategic thinking, especially thinking broadly, in diverse linkages and for long-term. Nevertheless, they were further analyzed, and utilized to finalize SMS by the researcher. The final materials were also distributed to the participants for final validation, leading to input for the next session. The methodology undertaken in Session 2 is explained in SIC given in Table 25.

The final SM, which is given in Figure 7, is constituted from seven perspectives; 1) Financial, 2) Market and Business Growth, 3) Stakeholder, 4) Project Management, 5) Governance and Compliance, 6) Sustainability, 7) Learning and Growth. The theoretical background of each perspective is given in following sections of this chapter. To be noted that; KPI-F and BSC of the Company are given in Appendix 5 and Chapter 5.4.1, respectively.

Table 25: Strategy Mapping Workshop

Session 2: Strategy Mapping Workshop	
General Information	
Session Topic	Strategy Mapping Workshop
Session Type	Group Modeling Workshop
Session Targets	• Validate Strategic Objectives Taxonomy • Validation of Strategy Map Structure
Session Duration	3 hours without any break
Participant Composition	
Size and composition	Top Management: 5 C-level managers

Management Support	Direct support: Workshop attendance and open conversation
Pre-Meeting Interviews	Pre-meeting interviews were not scheduled. However, pre-session materials (i.e. SOT, SMS) were distributed to the participants one week before the workshop day.
Session Procedure	
Pre-Session Study	• Development of the SOT • Development of BSC Perspectives based on SOT • Development of draft SMS
Session Input	• SOT (draft) • SMS (draft)
Session Agenda & Methodology	• Overview of SOT • Individual Causal Mapping to develop SMS • Group discussions on Individual Causal Maps • Overview of SOT and SMS • Finalizing Strategy Map Structure based on Group Discussions
Post-Session Study	• Finalizing SOT • Finalizing SMS
Plenary Sessions	Verbal statements were recorded to maintain opinions of Company. These statements were used by the researcher when finalizing the SMS
Session Output	• SOT (final) • SMS (final)
Methodology, Tools and Facilitation Aspects	
Tools and Techniques	Group Brainstorming, Individual Causal Mapping
Facilitators and their roles	Researcher was the facilitator. She opened dialogues, directed the session and interactively reflected the opinions of participants on the SMS developed in MS Visio and MS Excel. Researcher did not add or reject any opinion proposed by participants.
Risks & Limitations	**Risk 2.** Reliance on judgements and opinions of dominant participant **Risk 6.** Difficulties in achieving a consensus on strategic objectives **Risk 7.** Excessive time to review and discuss Strategic Objectives Taxonomy **Risk 8.** Difficulties in conducting and adapting "strategic thinking", tendency to focus on "operational" details **Risk 9.** Difficulties in achieving a consensus on interdependencies among strategic objectives **Risk 10.** Difficulty in prioritizing and defining causalities among strategic objectives **Risk 11.** Belief about each strategic objective is so important and eventually effect each other **Risk 12.** Excessive time to get participants used to and familiarize with the underlying theory of strategy maps
Anonymity & Permissions	Participants’ names, ideas and choices could be seen and shared by others. Participants could not reject or remove ideas of other participants. The company allowed to publish assessment and formulation results.

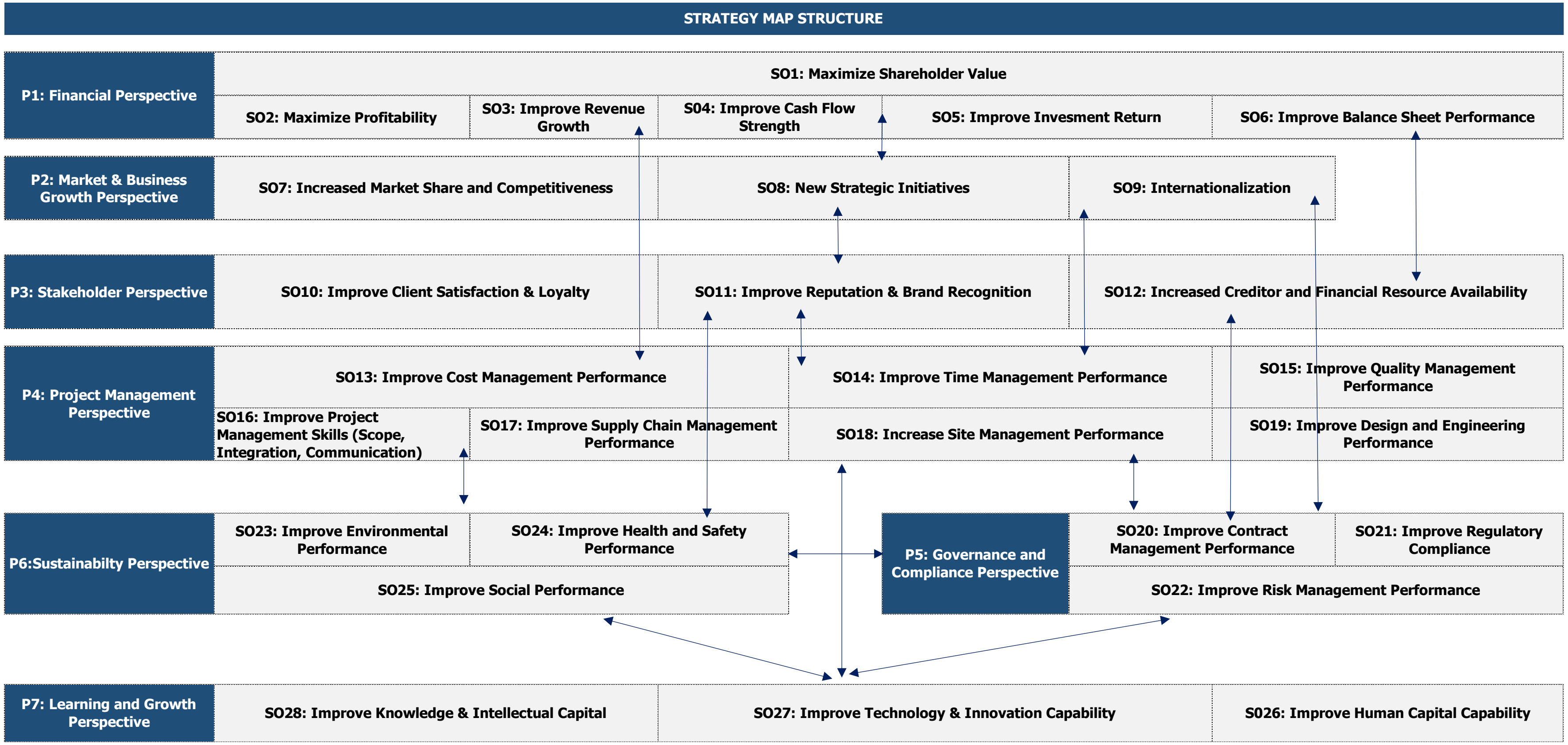


Figure 7: Strategy Map Structure

Scorecard Perspective 1: Financial Perspective

The first step in developing the BSC Structure is defining financial goals. As the goal of the companies are toward maximizing shareholders' wealth, the financial goals are generally shaped based on the price of the company's stock, profitability and revenue growth [1], [361]. Both in literature and in practice various measures are used to quantify return on net assets, cash flow, profitability and revenue growth. For example, "return on shareholder funds", "return on capital employed", "return on total assets and profit margin" [168] are highly applied to understand profitability and revenue growth of the companies. In addition to maximizing their revenue growth, almost every companies also foster to reduce their costs and utilize their assets in highest performance. [176]. In this regard, [176] summarized three key financial strategies taken by companies to enhance their financial performance;

- Revenue Growth representing the growth from both the existing and new customers and products,
- Productivity representing the reduction in variable and fixed expenses through increasing value in the process,
- Asset utilization representing the optimization of use of fixed assets in order to reduce overall cost per unit of output.

Both the theoretical literature as well as industry reports, are rich in defining KPIs to assess financial performance of companies. For example; [20] identified five KPIs for measuring financial performance; namely, 1) total asset turnover, 2) return on equity, 3) turnover growth rate, 4) operating profit, 5) per-capita sales. In their PM framework, [25] defined four KPIs to analyze financial performance of construction industry; namely, 1) return on equity and 2) economic value added both for assessing "profitability", 3) net sales growth rate for assessing "growth" and 4) debt ratio for "stability". The measures used in analyzing financial performance of organizations are similar in context as almost every private companies are responsible from similar financial statements such as statements given in IFRS.

In this study, financial measures such as return on investment, shareholder value, profitability, revenue growth [21], were taken as basis. They represent diverse strategic objectives included in the Financial Perspective of the BSC Structure. The Financial Perspective constitutes the top of the traditional BSC hierarchy by describing the tangible outcomes of the strategies premised. Taking causalities among strategies into consideration, strategic objectives associated with the "Financial Perspective" of the BSC Structure, are examined under six folds, as given in Table 26.

Table 26: Strategic Objectives in Financial Perspective

BSC Perspective	ID	Strategic Objectives
P1: Financial Perspective	SO1	Maximize Shareholder Value
	SO2	Maximize Profitability
	SO3	Improve Revenue Growth
	SO4	Improve Cash Flow Strength

	SO5	Improve Investment Return
	SO6	Improve Balance Sheet Performance

Scorecard Perspective 2: Market and Business Growth Perspective

Construction companies can improve their financial performance through increasing their international revenue and improving their resources from different markets ([362], [363], [20]). As captured from the theoretical base, various construction future studies have focused on international expansion, market and business growth as long-term strategies in order to maintain and improve competitiveness of their companies. As given in Figure 7, achieving strategic objectives in the context of market and business growth are highly associated with improving international competitiveness and strengthening global competitive position through winning new tenders in international markets. Based on the strategies offered in the Theoretical Base, strategic objectives associated with the “Market and Business Growth Perspective” are examined under three folds. As given in Table 27, these objectives are; 1) Increased Market Share and Competitiveness, 2) New Strategic Initiatives, 3) Internationalization.

Table 27: Strategic Objectives in Market and Business Growth Perspective

BSC Perspective	ID	Strategic Objectives
P2: Market & Business Growth Perspective	SO7	Increased Market Share and Competitiveness
	SO8	New Strategic Initiatives (partnerships, MA)
	SO9	Internationalization

Market share and competitiveness measures generally reflects the ability of construction companies to win new bids, entrance to new markets, sustain performance or increase international profit in longer time horizons [364]. The broadly utilized measures in this context are; level of market growth, growth in contract awards ([365], [366]) and sales growth [367], [140]. The market growth is highly related with the level of ability to do business in international arena, to work with international clients and other stakeholders to create opportunities for revenue growth.

Another strategic objective in the field of Market and Business Growth is the internationalization. It reflects the ability of the construction companies to expand their markets by winning new projects in international markets. Various index systems are utilized to explore the degree of international expansion of construction firms (i.e. [368], [369]). In general, the performance of international construction can be measured by overseas income, revenue growth in international markets or number of international bids won. However, as suggested by [20], economic conditions, market regulations, or market entry barriers highly influence the degree of international expansion and performance of construction firms in the international market. Thus, these external conditions are considered while defining measures for internationalization strategy.

Although internationalization is a crucial research area in the construction industry, current literature focus highly on either PM in construction (mostly focusing on domestic markets) or internationalization in construction (mostly focus on success of the internationalization process). This limitation necessitates studies exploring how both domestic support and international businesses can contribute to the sustained performance of the whole company [20]. In this study, it is aimed to cover both the international and national revenue growth, both of which will contribute to the overall competitiveness of firms.

Market performance is generally given as part of the customer perspective and regarded as the output of customer satisfaction and retention [173]. Although market performance in international markets can easily be translated into financial performance in other industries such as manufacturing, in international construction industry it not the case due to the low concentration ratio of the industry. In addition, international contractors generally focus to compete with their counterparts by providing diverse services in lowest cost and highest quality, which may hardly reflect the real economic situation of the firm, especially in small and medium sized contractors [20]. [370] and [31] also argued that market performance (i.e. market share) is a nonfinancial indicator that does not sufficiently result in financial outcomes, independent from the whether operating in international markets or not [20].

Scorecard Perspective 3: Stakeholder Perspective

Meeting the client expectations is one of the most important criteria to ensure business continuity. An ongoing and healthy working relationship with the clients is necessary to gain new projects. Companies generally tend to rely on traditional objectives of projects, such as completion of projects on time, within budget and with satisfactory quality. However, as the construction industry is also characterized by involving various stakeholders with quite diverse business objectives, reliance on solely these project objectives might not be adequate to meet client expectations and ensure business continuity. Concerns of other stakeholders such as end users, developers, sponsors or investors, various institutions, and local governments should also be considered to ensure long-term satisfaction of the clients. In addition, wide range of interests of these stakeholders should be ensured such as sustainability, reputation, human rights or social responsibility, which are generally overlooked by organizations ([20], [371], [167]). Similar to [142] and [20], capturing only the clients' requirements through the customer perspective of the original BSC is not sufficient to reveal diverse objectives of these stakeholders. A broader Stakeholder Perspective is needed to embrace all stakeholders' concerns and interests, including those of clients. Focusing on whole stakeholders is especially critical for companies those striving to compete in the international construction market [20], due to involvement in different cultural, political and economic environment.

In addition, in recent environment, stakeholders are becoming more interested in business process, sustainable development and governance issues beyond financial performance [372]. As discussed by various authors ([372], [373]) investors or creditors generally want to ensure good corporate governance, sound business strategy and effective risk management. Clients generally ask origins of products, who made them or what they contain. Employees are looking for social and environmental responsibility and accountability of their companies. Governments and civil society place pressure on companies to report their sustainability performance [373]. As discussed in the forthcoming sections, the increasing attention of stakeholders in sustainable development and governance lead to examine the strategies associated with these issues under different perspectives. Such that; strategies about meeting the requirements of societies, regulatory bodies or local governments are examined under "Sustainability" and "Governance and Compliance" Perspectives due to their importance of the Company given to them. In addition, the strategies associated with the remaining stakeholders (clients, creditors etc.) are examined under "Stakeholder Perspective"; forming three strategies objectives as depicted in Table 28. However, "Sustainability", "Governance and Compliance" and "Stakeholder Perspectives" are highly dependent to each other such that poor performance in "Sustainability" and "Governance and Compliance" will eventually lead to damages in corporate reputation, which in turn decrease credibility of the organization, resulting in poor financing and client satisfaction.

Table 28: Strategic Objectives in Stakeholder Perspective

BSC Perspective	ID	Strategic Objectives
P3: Stakeholder Perspective	SO10	Improve Client Satisfaction & Loyalty
	SO11	Improve Reputation & Brand Recognition
	SO12	Increased Collaboration with Creditors

The first strategy included in the Stakeholder Perspective is the "improving client satisfaction and loyalty". It is about ensuring old customers to continue to award new projects to the Company. Some strategic initiatives to increase customer retention are also defined by the Company as; improving relationship with customer, responding to their complaints or suggestions and offering support services after the projects are closed. In addition to ensuring satisfaction of the existing clients, customer acquisition, which is about collaborating with new customers, is also considered under this strategic objective. In general, major strategic initiatives taken by the companies to increase customer acquisition are; entering and penetrating to new markets or constructing new type of projects [374].

The second strategic objective is the "improving reputation and brand recognition". Reputation is "a perceptual representation of a company's past actions and future prospects that describe the firm's overall appeal to all its key constituents when compared to other leading rivals" [375]. It is more about the value/ image of the companies by their previous efforts for which managers generally engage in explicit reputation-building activities (i.e. advertising, sponsorships) in order to improve their firms' reputations [375]. The studies of various authors (i.e. [376], [377], [375]) revealed that good corporate reputation enables better financial performance through serving a signal of employing high performed talents, quality of firm's products and services, enhanced market force and ensured client satisfaction. Indeed, firms with goods reputations have greater opportunity to engage in projects that further enhance their reputations, which creates a virtuous cycle among reputation and other strategic goals [375]. In other words; reputation and financial performance of companies have bidirectional causality such that; financial performance of companies improve their positive reputation, while positive reputation contributes their financial performance ([378], [375]).

The study conducted by [20] also revealed, "achieving excellence in sustainability, social responsibility and international reputation are regarded as the most important ways to gain a sustained competitive advantage in the construction market". In this regard, as depicted in Figure 1, while strategic objectives given in Sustainability Perspective influence Stakeholder Perspective through "Project Management Perspective", it also has a direct effect on "Stakeholder Perspective".

In addition to the reputation, brand equity is defined as "the differential consumer response from knowing the brand" ([379], [380]). Loyalty of consumers is one the most critical indicators for brand equity as brands having larger market share highly stand for the highest levels of loyalty [380]. [380] describes the phenomenon as; loyal customers are not as switchable in the face of competitiveness or they do not require the same extent of deals or promotions while compared with the less loyal customers. Thus, brand equity and reputation are two of the most valuable assets of the companies, which determine the level of customer loyalty and satisfaction, which in turn contribute to financial performance of companies. These bidirectional relations are reflected to the SMS in relation among "SO10: Improve Client Satisfaction & Loyalty" and "SO11: Improve Reputation & Brand Recognition".

Scorecard Perspective 4: Project Management Perspective

In the early studies, the success or failure of construction projects is generally evaluated by in what extent the cost, time and quality objectives of clients are met [141]. However, those objectives, which are seen as the "three traditional indicators of performance" [381], are lack of providing a balanced view of the project performance. They typically provide a picture about the performance at the end of the project, that is they are "lagging" rather than "leading indicators" of performance [47]. With the emerging interest in these areas as well as with the increasing use of Project Management Body of Knowledge (PMBoK), traditional project management objectives are transformed for more structured and comprehensive point of view, which necessitates a special focus on other knowledge areas such as scope, procurement, health and safety, and human resources management.

Both in theoretical literature and in practice, various organizations utilize nine processes proposed by PMBoK to establish BSC on project performance [382]. PMBoK Guide was developed by Project Management Institute (PMI), which was found in 1969 by five project management specialist; Gordon Davis, "Ned" Engman, Susan Gallagher, Eric Jenett, and James Snyder [383]. Their major purpose was to "to provide a means for project managers to associate, share information and discuss common problems" [383]. Since it has established, PMI has enabled the foundation of project management knowledge and expansion into various industries, including construction industry. The project management knowledge areas developed by PMI in PMBoK, are now regarded as best practices in project management field. During the development of “Project Management Perspective”, the Fifth Edition of PMBoK Guide of PMI was taken as basis [357].

Project Management Perspective also shows the internal processes that construction companies must excel. The premise behind this perspective is that it defines what the companies must to do internally in order to meet its customer’s expectations [1] such as undertaking the project within budget, schedule and quality targets. So that, some common set of measures were included in this perspective such as; cost of quality, cost of non-conformance, time variation, or defect rates.

The strategic objectives associated with the “Project Management Perspective” are examined under seven folds, as given in Table 29. The term “cost” in cost management objective is about “the degree to which the general conditions promote the completion of a project within the estimated budget [384]. It is “not only confined to the tender sum, it is the overall cost that a project incurs from inception to completion, which includes any costs arise from variations, modification during construction period and the cost arising from the legal claims, such as litigation and arbitration” [385]. In addition, scope is related to the definition and boundaries of work performed to deliver a product, service or result with the specified functions and conditions. As described by [357], project scope management is about “processes required to ensure that the project includes all the work required, and only the work required, to complete the project successfully”. Quality is about fitness for purpose [386], which is “the totality of features required by a product or services to satisfy a given need” [385], while time refers to delivering the scope of work under contractual schedule obligations.

Table 29: Strategic Objectives in Project Management Perspective

BSC Perspective	ID	Strategic Objectives
P4: Project Management Perspective	SO13	Increase Cost Management Performance
	SO14	Increase Time Management Performance
	SO15	Increase Quality Management Performance
	SO16	Increase Scope Management Performance
	SO17	Improve Procurement & Supply Chain Performance
	SO18	Increase Site and resource management performance
	SO19	Improve Design and Engineering Performance

Scorecard Perspective 5: Corporate Governance Perspective

The term “corporate governance” has been widely used since the mid-1980s with the economic and political changes arise in the Organization for Economic Co-operation and Development (OECD) countries [387]. According to [388] corporate governance “is the mechanism through which the managers’ control is monitored and held to fairly enhance corporate profit and shareholder gain”. Corporate governance is defined by [389] as ‘‘system by which companies are directed and managed whose major intention is to increase the corporate performance and accountability in the interests of both shareholders and the broader community". It is some set of structures and systems, those utilized by who have a legitimate stake in an organization to control and ensure accountability of managers [53]. It can also be facilitated as the institutionalization of rules those required to avoid reliance on quick wins, which might entail adverse long-term consequences [390]. In this study, corporate governance and compliance is associated with the contract and litigation management, regulatory issues for compliance purposes as well as risk and audit management for governance purposes. In line with this definition, the strategic objectives associated with the "Governance and Compliance Perspective" are examined under three folds; as given in Table 30.

Table 30: Strategic Objectives in Governance and Compliance Perspective

BSC Perspective	ID	Strategic Objectives
P5: Governance and Compliance Perspective	SO20	Improve Contract and Litigation Management
	SO21	Improve Regulatory Compliance
	SO22	Improve Risk and Audit Management

As the existence of an effective corporate governance system is expected to have positively influence on both financial and non-financial performance of organizations [391], objectives given in "Governance and Compliance Perspective" directly or indirectly influence various other strategic objectives, especially those related with the Stakeholder and Financial Perspectives. Some studies reported the association of effective corporate governance practices on financial performance of organizations. The study of [392] also revealed organizations with effective CG practices deliver greater stock returns, higher values of Tobin's Q and healthier cash flows while compared with their counterparts.

Various researchers have also promoted instruments of corporate governance as a solution for agency problems (i.e. [393], [394], [395], [396]). It is a regulatory activity enforced by diverse internal and external agencies to resolve the agency conflicts and protect the stakeholder interests [396]. It encourages the corporations to promote and ensure ethics, fairness, transparency and accountability in their businesses [397] enhances a disclosure-based environment [398] and prevents self-interested managerial behavior [391] and force managers to act in the interests of both shareholders and stakeholders [398]. Nevertheless, it ensures that organizations are run in a responsible, accountable manner and in charge, which in turn enhances the overall performance and enables meeting with the expectations of various stakeholders.

Despite its importance, to date various authors have criticized the PM applications of firms those do not consider governance principles. For example, [399] appealed the missing perspective in BSC implementations as the corporate governance dimension. [400] suggested the development of a board BSC that includes corporate governance variables, in order to enhance SP at the board level. According to [400] an effective BSC program should include three parts, an enterprise BSC, a board BSC, and an executive BSC. The top most scorecard, enterprise BSC, describes the organization's strategy, goals, performance measures, targets and initiatives to be implemented by the CEO and managers, which in turn enables to monitor the implementation of the organizational strategy. The second level, board BSC, defines the strategic contribution of board by holding information about data needed for board operation. [400] claimed board BSC is an instrument for shareholders to check the performance of board and its committees and to implement corporate governance dimensions. Authors added that the enterprise BSC and board BSC should share the same financial goals, as the ultimate role of the board is to maximize the long-term return to shareholders. The latter scorecard is executive BSCs those enable board of directors and the compensation committee to measure performance of executive management or top managers of the organization.

Despite their rarity, there also exist some other efforts to relate corporate governance with firm performances, sustainable growth or portfolio selection. For example, [391] analyzed the relationship among environmental reporting and corporate governance attributes of Australian companies and found a significant positive relationship between the extents of environmental reporting. [401] offered a novel model for measuring and monitoring the sustainability of corporate governance by utilizing 12 major elements. [402] examined the usefulness of governance attributes on portfolio selection by the idea that corporate governance increases the value of the firm. [403] assessed the relationship between internal governance structure and financial performance of selected Spanish companies. [392] investigated corporate governance issues in India and establish the relationship between corporate governance and financial performance utilizing the data comprised from 141 companies belonging to the “A” group stocks listed in the Mumbai Stock Exchange of India.

These studies on corporate governance has widely focused on structural dimensions of boards such as; board size, board independence, CEO duality, and activity of various board sub-committees, board structure and managerial ownership. A substantial body of studies have focused; executive compensation, external audit committees, sphere of business ethics (i.e. codes of ethics, ethics management systems, ethical corporate culture and ethical leadership). Some of the studies that have attempted to construct corporate governance measures can be found from [404] (38 governance measures), [405] (24 governance measures), [406] (24 governance measures) and [407] (51 governance factors). Thus, KPIs associated with the “Governance and Compliance Perspective” were also defined based on these structural dimensions which have widely used in current literature.

Scorecard Perspective 6: Sustainability Perspective

The sustainable development concept has first defined in Environmental Quality Report prepared by While House Council in 1981 [408]. As defined by the Council, the underlying concept of it is “the economic development has to proceed by also protecting the natural resources if it is expected to be successful over the long term”. It is defined in the report “Our Common Future” prepared by Brundtland Commission as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [409]. The World Commission on Environment and Development has defined “sustainability” as “economic development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs [410]. The concept of sustainability formerly referred to how organizations handle non-financial factors such as environmental, social and economic issues. It embraces broader range of issues in ecology, sociology, environment, well-being of people and standard of life all of which can be perceived as “green” practices inherit in all type of business operations [411]. Sustainability issues are strategic as any adverse outcome in sustainability may influence company’s image, profitability, competitiveness, markets and products, all of which will affect the future economic survival of companies ([412], [413]).

The concept of Corporate Social Responsibility is also the general trend for emphasizing the social aspects of sustainable development. Social performance indicators of sustainability largely include; accountability, reporting, employee diversity, labor relations, safety, community human rights, transparency, relations with suppliers, and anti-corruption. The social aspects of sustainability are generally linked to the human resources as well. GRI, one of the flag carrier initiative in sustainability reporting, requires reporting social aspects in four sections;

- **Labor Practices and Decent Work indicators:** Employment, Occupational Health and Safety, Training and Education, Diversity and Equal Opportunity, Equal Remuneration for Women and Men,
- **Human Rights indicators**: Non-discrimination, Child labor,
- **Society indicators:** Public policy,
- **Product responsibility indicators:** Products and Services Labelling.

The concept of sustainability may differ among organizations as well as the selection of measures to assess sustainability performance is based on the strategies of the organizations about sustainability [410]. Various authors have recommended incorporating sustainability into existing corporate measurement systems as a one way to tie performance metrics for sustainability to corporate strategies (i.e. [414], [411], [410]). One of the most recommended tool to measure sustainability performance is BSC (i.e. [414], [415], [267], [416]). BSC is a helpful tool by clarifying the relation among sustainability and financial outcomes through incorporating sustainability measures into business practices as well as defining the link among competitive strategies of organizations and its green outcomes [411].

Some examples about performance measures about the sustainability concept can be found in the studies of [411], [410], [410], and [414]. For example; [411] added sustainability perspective in traditional BSC to measure the sustainability outcomes of organizations. [410] defined environmental and social metrics and added them into standard four perspectives. [410] developed a sustainability linkage map as well as defined financial and non-financial metrics to measure sustainability performance. Authors classified measures of sustainability actions in three groups; sustainability strategy, plans/programs and structure/systems. For example; sustainability strategies defined by the authors cover; increasing number of facilities with screening procedures against the use of child labor, increasing gender diversity with respect to % of work force, reducing lost workdays, and reducing emissions. The plans and programs were exemplified as; $ of investments in clean technologies, safety training programs and support programs for minority-owned businesses with respect to % of business volume. The last item, structure and systems, were proposed as; ISO 14001 certification, social performance evaluation systems, environmental accounting systems and senior managers with social and environmental responsibilities. [414] developed a sustainability BSC that considers the dependencies of the three pillars of sustainability; environmental, social and economic performance. [373] categorized sustainability indicators into three folds; a) in-house indicators, b) management indicators, c) stakeholder/business partner indicators. In-house indicators are about social and environment aspects such as; energy, water, air, waste, working environment, job creation, training and personnel development, diversity and equal opportunities and code of conduct. Management indicators highly related with corporate governance indicators such as compliance, business performance, management systems, bribery and corruption, and auditing. The last, stakeholder indicators, are associated with external environment such as reputation, local community, social performance reporting, customers, suppliers/contractors and shareholders.

[414] suggested three alternatives to incorporate sustainability in BSC structures [414]. The first alternative is environmental and social aspects of sustainability can be integrated in the existing four standard perspectives so that they automatically become an integral part of the scorecards (i.e. measures about energy costs, recycling revenues, disposal costs and cost of environmental damages added in financial perspective). As a second alternative, authors recommended adding a perspective dedicated to sustainability if the strategic relevance of environmental and social aspects could not be reflected with the four standard BSC perspectives or these aspects represent strategic core aspects for the execution of company strategy. Adding a perspective about sustainability measures is seen as the simplest and most likely approach for companies that aim to include sustainability as a key corporate value. The last approach is about developing a specific and separate scorecard dedicated to sustainability issues.

The choice of which approach to tie sustainability into performance measures, is dependent upon the challenges facing the organization as well as its degree of commitment to sustainability. As exemplified by [410], companies, which are more sensitive to community stakeholder pressure or which operate in a tight labor market, might show more willingness to incorporate environmental and social issues into their corporate strategies. These companies may expand their scorecard by adding sustainability as a fifth perspective and link it with standard four perspectives [410].

The SMS, given in Figure 7, includes a separate Sustainability Perspective in this regard, as the construction industry is sensitive to community stakeholder pressure due to its high level of resource and energy consumption and being prone to health and safety risks. In this regard, a separate Sustainability Perspective was developed and three major strategic objectives were developed under this Perspective, as given in Table 31.

Table 31: Strategic Objectives in Sustainability Perspective

BSC Perspective	ID	Strategic Objectives
P6: Sustainability Perspective	SO23	Improve Environmental Performance
	SO24	Improve Health and Safety Performance
	SO25	Improve Social Performance

The Sustainability Perspective is also highly interrelated with "Learning and Growth", "Governance and Compliance", "Project Management" and "Stakeholder" Perspectives, as depicted in Figure 7. Various authors have also studied the bi-directional causality of sustainability with other corporate and project success measures. For example, [410] argued improved sustainability performance enable improved employee satisfaction, lower operational and administrative costs, better productivity, enhanced image and reputation, increased market opportunities, better shareholder relationships, and stock market premiums.

[417] examined the causality between sustainability and financial performance based on two theories; 1) slack resources theory and 2) good management theory. "Slack Resource Theory" argues success in financial performance eventually leads to availability of slack (financial and other) resources those can be utilized to invest in social performance domains such as employee satisfaction, environment protection or community relations. Alternatively, "Good Management Theory" argues that sound sustainability performance improves relations with stakeholders, which result in better corporate performance. These two theories represent two bi-directionality of sustainability with other perspectives, as also exemplified in Figure 7. Such that; the forward loop inherent in SMS represents "Good Management Theory", that is similar to the example given by [417], excellent community relations might provide regulatory compliance, thereby reducing probable costs to the firm and improving the financial performance. In addition, the feedback loop inherent in SMS represents "Slack Resource Theory" that is, increase in financial performance can contribute to invest in development of more structured and mature systems to improve sustainability. As also argued by [417], similar to the other perspectives, "Sustainability Perspective" has virtuous cycles with other perspectives given in SMS.

The identification of performance measures for sustainability might be complex and vague, as they differ among companies due to different levels of importance attached to it [410]. As also recommended by [373], during the identification of KPIs for Sustainability Perspective, one of the highest internationally recognized standard, GRI, was utilized. However, as exemplified in Table 32, there also exists reports and standards of other international organizations and initiatives on environmental, social and corporate governance (ESG) issues. To be noted that; ESG reporting frameworks (i.e. GRI) given in Table 32 generally support financial reporting standards (i.e. IFRS and US GAAP) in order to reflect integrated economic performance of companies [418].

Table 32: International Organizations Focusing on Sustainability

Organization	EN	S	EC	G
UNEP FI: United Nations Environment Program Finance Initiative	X	X		X
IFRS: International Financial Reporting Standards			X	X
US GAAP: US Generally Accepted Accounting Principles				
EFFAS- DVFA: The European Federation of Financial Analysts Societies- Society of Investment Professionals in Germany	X	X		X
UN PRI: Principles for Responsible Investments	X	X		X
OCED: The Organization for Economic Co-operation and Development	X	X	X	X
GRI: Global Reporting Initiative Sustainability Reporting Guidelines	X	X	X	
UNCTAD: United Nations Conference on Trade and Development	X	X		X
IFAC: International Federation of Accountants	X	X		X
IIRC: International Integrated Reporting Council – Integrated Reporting	X	X	X	X

EN: Environment, S: Social, EC: Economic, G: Governance

Scorecard Perspective 7: Learning and Growth Perspective

Learning and Growth Perspective is taken as basis in various BSC methods reported in current literature. This perspective measures the performance or capabilities of employees (i.e. skills, talents, knowledge, motivation and training), the quality and availability of technological capital (i.e. information systems, research and development, innovation) as well as the maturity of organizational knowledge capital (i.e. knowledge assets such as culture, leadership, procedures, and learning capability). The strategic objectives associated with the "Learning and Growth Perspective" are examined under three folds, as given in Table 33.

Table 33: Strategic Objectives in Learning and Growth Perspective

BSC Perspective	ID	Strategic Objectives
P7: Learning and Growth Perspective	SO26	Improve Human Capital
	SO27	Improve Technology Capital
	SO28	Improve Knowledge Capital

Amongst all, human capital is one of the most crucial organizational assets both from organizational resources and from corporate responsibility point of view. From both view, the main leading factor to ensure human capital is ensuring their motivation and satisfaction. Employee motivation and satisfaction are needed both to be a responsible employer and to ensure success of the companies. The regular monitoring and assessment of team motivation is of paramount importance as it directly affects the successful completion and quality of projects [131].

Various authors have defined measures to evaluate the team satisfaction and motivation, which are generally quantified via team surveys or face-to-face interviews. For example, [131] included an index for project team satisfaction, which was analyzed by earned rating for area of concern of teams with priority assigned to each concern though team surveys. [168] proposed employee-related performance measures have paramount importance in the construction industry such that, more than ten measures about employee-issues were defined in the UK construction industry to evaluate “respect for people” [307]. Authors added; “profit per employee”, “turnover per employee” and “average remuneration per employee” are utilized to measure employee productivity and concerns in the UK construction industry. In addition to the employee motivation, employing skilled human capital and improving talents are of critical performance measures for success of organizations.

Although at the individual level, organizational capabilities include personal knowledge and individual skills and talents, at the organizational level, these capabilities consist network relationships, technologies, infrastructure, organizational routines, procedures and culture [419]. Knowledge is seen as major driver of today’s company life and wealth-creating capacity [420]. That is why; various organizations foster organizational learning to pursue continuous improvement in their knowledge assets [62].

Learning organization is defined by [421] as “one that learns continuously and transforms itself. Learning is a continuous, strategically used process, integrated with and running parallel to work.” Various definitions exist for the term of learning organization; however, the general focus is on acquiring, storing, improving, transferring and re-using knowledge, incorporating individual knowledge and expertise to promote collective learning and enhance practices of organization through utilizing collective and disseminated knowledge [361].

Knowledge management is also highly interpreted with intellectual capital. Intellectual capital is a portfolio of organizational knowledge [419] that can be classified as assets (i.e. brand, trademark, contracts, and databases) and skills (i.e. knowledge of employees, organizational culture) [422]. Intellectual capital generally consists intangible assets that can be converted into value [423]. Some examples of these assets are; brand equity, knowledge of workers, corporate culture, stakeholder relations, access to markets, competitive position and a host of other off-balance sheet resources [424].

Due to the project-based nature, which requires temporary project management teams, learning capacity and implementation of lessons learned are known as weak in the construction industry [20], which makes it more critical to include knowledge-related measures in BSC [47]. In addition, as the construction industry is also characterized as a conservative rather than innovative industry, various industry reports and excellence initiatives see continuous learning and growth as an opportunity for construction improvement [20].

Being a learning organization is also related with the innovation capability of organizations, which is one the key drivers of effectiveness and success of organizations. It is about the organization’s ability to engage in innovation that is creating and introducing novel processes, products or ideas in organization [425].

However, despite the advances in technology and innovation, companies generally do not measure or monitor innovation performance, indeed do not have any internal systems or processes to measure it ([426], [425]). However, the innovation and learning capability are highly associated with both financial performance and competitiveness of organizations. For example, [361] explored positive causality among learning organization concept to the financial performance of firms by conducting study using Watkins and Marsick Dimensions of the Learning Organization Questionnaire. Learning organizations are also reported as being market-oriented, having a collaborative, entrepreneurial and innovative culture, enhancing leadership skills [361].

In this study, “Learning and Growth Perspective” has a bi-directional causality with “Project Management Perspective”, “Sustainability Perspective”, and “Governance and Compliance Perspective”. The strategic objectives covered under “Learning and Growth Perspective” have also bi-directional causality such as improved human capital can lead to high knowledge dissemination and learning capability, which eventually contribute to innovativeness and technological advancements.

5.4. STRATEGY IMPLEMENTATION

5.4.1. Key Performance Indicators

Many conceptual frameworks exist for measuring performance of construction companies, such as those of [47], [40], [25], [43], [162], [140], and [20]. Various KPI-based benchmarking programs have also developed worldwide; such as in USA [146], UK [427], and Canada ([149], [150]). Although these KPI programs largely focus on lagging indicators and limited in feedback and future learning loops [164], they are still beneficial as they provide a knowledge basis for the development of diverse KPIs. They also provide companies to compete their performance against competitor’s best practice [1]. According to [152] the need for benchmarking rise with the necessity of comparing the measured level of success to something. Based on the need, authors defined benchmarking as a process of identifying value/ target of metrics against which those metrics are to be compared.

The KPI-F proposed in this research, was also developed based on the available benchmarking initiatives of the construction industry. Some of these initiatives are,

- Global Reporting Initiative (GRI) [428],
- KPIs in the United Kingdom (KPI- UK) [145],
- Glenigan UK Industry Report (GLENIGAN) [307],
- National Benchmarking System for the Chilean Construction Industry (NBS-Chile) [154],
- Construction Best Practice Program [148],
- Performance Measurement System for Brazilian Construction Industry (SISIND) [155],
- Construction Industry Institute Benchmarking and Metrics form the United States of America [144].

Prior to the identification of the KPIs, firstly a structured process was developed about how to define these KPIs in order to overcome complexity involved in the process. After a review on current literature, methodologies offered by [373] and [25] were taken as basis for the KPI Identification Process as explained Table 34.

As depicted in Figure 7, SMS contains seven perspectives, 1) Financial, 2) Market and Business Growth, 3) Stakeholder, 4) Project Management, 5) Corporate Governance, 6) Sustainability, and 7) Learning and Growth. In order to translate the strategic objectives into some operational terms [1], KPIs associated with each perspective were identified based on the process given in Table 34.

Table 34: KPI Identification Process

Aim	Analysis	Input	Method	Consideration
To develop a KPI Framework	Qualitative	BSC perspectives	Literature review Benchmarking initiatives Sector Reports	Validity
To find feasible KPIs	Quantitative	Candidate KPIs	Structured Focus Group Interviews	Suitability Simplicity Measurability
To select final KPIs	Quantitative	Relevant KPIs	System Dynamics Modelling	

To do so; firstly a KPI-F was established via content analysis on the primarily benchmarking initiatives. Some other supporting studies were also utilized such as; studies from construction industry literature, annual reports of construction companies, or reports of international and EU-based institutions. After the detailed review, KPIs for each perspective were identified by the researcher forming the final KPI-F as given in Appendix 5.

To shortlist the KPI-F, the KPIs given in the framework were reviewed and ranked by the director-level specialists of the Company in the Focus Group Interviews. The Interviews were undertaken for each perspective given in the SMS separately in order to test the validity of the KPIs and select feasible KPI's from the KPI-F. To do so, some pre-defined attributes were provided to the specialists in order to enhance accuracy and validity of the session, itself. After feasible KPIs were selected in the Focus Group Interviews, they were further evaluated by the Company Experts to select final KPIs. These final KPIs were further used when developing Company-specific BSC Structure as well as when developing the Computerized Model using SD method.

5.4.2. KPI Attributes

The design of a KPI itself is a process with having inputs and outputs, which necessities a structured approach [429]. Some description and evaluation criteria for KPIs are needed to systematize the KPI Identification Process given in Table 34. These criteria can also be useful to simplify the process of identifying KPIs as well as assessing them with Company Experts to define Company-specific KPIs. Thus, some sorts of “attributes” were developed to describe both the typological characteristics of KPIs as well as evaluation criteria of them.

These attributes were further classified under two folds; 1) expository attributes defining the general characteristics of KPIs, and 2) determinative attributes defining the selection criteria for given KPIs.

5.4.2.1. Expository Attributes of KPIs

Diverse amount of potential measures imitates the complexity inherit in today’s business, which necessitates KPIs to be a mix of leading/lagging, financial/ nonfinancial, external/internal, strategic/ tactical, process/product, people/ technology, and input/output measures [430]. The KPIs should be “quantifiable, in either absolute or percentage terms, as well as complete and controllable” [431]. “Complete” means the relevant measure fully reflects the elements of performance that matter, such as profitability is a summary measure of revenue generation and cost control. However, “controllable” is about ability of organizations’ controllability on the selected measures, which shows the “real” performance of organization [431].

Putting the “completeness” definition of [431] at the forefront, it is aimed to describe the KPIs with its typological elements. These typologies reflect whether the defined KPIs are leading or lagging, financial or nonfinancial, external or internal [430]. In this regard, “Expository Attributes” were defined as the attributes those explain or describe characteristics of KPIs such as their polarity, level, orientation, quantification method. In this context of this research; five types of expository attributes were defined namely; 1) causality, 2) level, 3) unit, 4) measurement method, and 5) polarity. The attributes of each type are summarized in Table 35. To be noted that, KPIs given in the KPI-F were fully described with its Expository Attributes, which are given in Appendix 5.

Table 35: Expository Attributes of KPI Framework

Attribute	Context
Causality	Leading / Lagging
Level	Corporate/ Project / Both
Unit	$ / Percentage/ Ranking
Measurement Method	Qualitative / Quantitative
Polarity	Maximize/ Minimize/ Based on Target

Causality: Causality defines whether the given KPI is a leading indicator representing performance drivers or a lagging indicator reflecting outcome measures. Outcome measures without performance drivers are lack of representation of how the outcomes can be achieved. Conversely, performance drivers without outcome measures fail to represent how the operational improvements can be translated into organization-wide strategy [169]. In this context, lagging indicators are generally known as generic or core outcome measures of BSC such as profitability, market share and customer satisfaction. The leading indicators, however, are the performance drivers that tend to be unique for a particular business unit or industry. Indicators representing internal processes, learning and growth measures, or specific market measures are some examples for leading indicators [169]. In this study, leading measures of the BSC were generally structured in the “Learning and Growth”, “Sustainability, “Governance and Compliance”, “Project Management” perspectives, while lagging measures were defined in “Market and Business Growth”, “Stakeholder” and “Financial” perspectives.

Level: Level reflects whether the given KPI is oriented towards the performance measurement of a support service, of a project or a whole organization. For example, in “Sustainability Perspective”, “accident frequency” can be used to assess performance of the project team in the field of OHS. However, in the same perspective another KPI named, “level of screening of suppliers and subcontractors on human rights”, can be used to measure success of support services in the corporate responsibility rather than focusing on project performance. At last, some other KPIs could also be used for both support services and projects such as “level of discrimination”, which is also measured in the context of Sustainability Perspective.

Unit: Unit reflects the dimension of a KPI which can be represented in “$” to reflect measures related with cost, savings or amounts, “%” to reflect measures related with variance, increase or decrease as well as “dimensionless” to reflect measures related with rankings or scores. KPIs, which are measured quantitatively, generally have units of “$” or”%”, while KPIs, which require qualitative assessment probably based on the rankings or scores a unit.

Measurement: Measurement reflects whether a KPI can be measured through a qualitative method or a quantitative method. KPIs, which have a mathematical formulation, can be measured quantitative methods, as expected. However, KPIs, especially reflecting a score, rating or soft issues highly require managerial decisions or judgement, which are qualitative in nature. For example, in “Stakeholder Perspective” while “client turnover rate” can be quantitatively measured by proportion of “number of clients’ lost” to “total number of clients”; “client satisfaction index” requires qualitative responses of clients about their satisfaction.

Polarity: Polarity reflects the desired outcome of a given KPI. For example, financial goals of organizations are highly associated with increasing the revenue and profitability in the meantime decreasing their administrative costs. Thus, while the polarity of “revenue growth” and “profitability” can be regarded “maximize”, the polarity of “administrative costs” can be “minimize”. A third type of polarity was also defined, namely, “based on target” which was utilized when a clear distinction could not be made and the direction of the target depends on the organizational strategies. For example, “asset utilization” is one these measuring having a polarity of “based on target”. It was quantified by the proportion of total revenue to total assets of an organization, which requires managerial decisions to set a target.

5.4.2.2. Contextual Attributes of KPIs

In addition to the Expository Attributes, some others are also needed to analyze the KPIs from different fields. To do so, Determinative Attributes are developed to describe evaluation criteria for a list of KPIs so that these KPIs could be assessed, refined and customized in a structured manner. In this regard firstly, different taxonomies or evaluation criteria offered in the literature for the selection of KPIs or other performance measures were reviewed.

[171] proposed seven criteria for selecting performance measures namely; a linkage to strategy, ability to quantify, accessibility, ease of understanding, counterbalance, relevance, and common definition. [164] suggested five selection criteria which include acceptability, suitability, feasibility, effectiveness, and alignment. [25] applied a more simplified list of selection criteria that consists validity, measurability, and comparability. [25] classified KPIs into three groups, 1) leading and lagging indicators, 2) key performance outcomes, and perception measures, 3) headline, operational, and diagnostic indicators ([63], [145], [164]). The screening criteria of KPIs defined by [373] are; 1) able to measure progress over time, 2) measurable and verifiable, 3) relevant to key internal/ external concerns, 4) potentially benchmarkable, 5) critically activity-related, and 7) meaningful at group level.

A special focus is also needed to relate how the selected KPI will contribute to the corporate strategy and agenda. Having diverse goals might lead to assess wide range of strategic issues across a number of processes [432]. However, [46] stressed the risk of selecting KPIs in a way that they are large in number but are not completely related to the strategy, which in turn lead to measuring everything but little matters to organizational strategies. Thus, some attributes, named “Contextual Attributes” are needed to evaluate the relevancy of KPIs to the overall organizational strategies.

Another issue to consider when selecting a KPI is that its acceptance by organizations. Management show willingness only if measures embrace the corporate agenda, they get the support they need about the measures and they believe the expected benefits of using that kind of measures ([433], [174]). Thus, KPIs should represent the interests and focus of the organization about which measure to use, how to use it. For example, while an organization might define “number of hours spent by employees on training” to measure training; another might be more interested in “level of competency related to the training” [174]. So, even same strategies or activities might be measured with numerous KPIs, selection of which is based on the organizational interests, routines and focus. Thus, contextual attributes are needed to make the decision makers consider the level of acceptance of KPIs.

In this regard, Contextual Attributes were defined under three folds; 1) relevancy and suitability, 2) simplicity, 3) accessibility and measurability. Definitions of these attributes in Oxford Dictionary as well as their contextual usage in this research are summarized in Table 36.

Table 36: Contextual Attributes of KPI Framework

Attribute	Definition in Oxford Dictionary	Context in this research
Relevancy & Suitability	The quality of being right or appropriate for a particular person, purpose, or situation	The quality of being right, appropriate and consistent for measuring the selected strategic objective
Simplicity	The quality or condition of being easy to understand or do, uncomplicated in form or design	Simple in context, easy to understand and communicate throughout the organization
Accessibility & Measurability	The quality of being a) able to be reached or entered, b) easy to obtain or use, c) easily understood or appreciated	Accessibility of data, survey result, expert opinion etc. to assess the specific measure

The selected Contextual Attributes, are also in line with the success criteria defined by [53] for decisions on strategic options. In their book, [53] defined three key success criteria, which are expected to analyze feasibility of strategic options;

- Suitability is concerned with whether a strategy addresses the key issues relating to the strategic position of the organization.
- Acceptability is concerned with the expected performance outcomes of a strategy and the extent to which these outcomes meet stakeholder expectations.
- Feasibility is concerned with whether a strategy could work in practice and whether the organization have necessary capabilities to deliver a strategy.

5.4.3. Selection of KPIs

As explained in Chapter 5.4.1, a KPI-F was developed by the researcher primarily based on the benchmarking initiatives. In order to select a final list of KPIs, which was further utilized to develop BSC Structure, iterative focus group interviews were held with director-level specialists of the Company. Focus Group Interviews were conducted separately for each BSC Perspective, ending up seven separate interviews, however all of which were regarded as Session 3. Breaking down the overall BSC Structure into smaller perspectives reduced the complexity of the interviews. In addition, as the KPI-F includes vast amount of KPIs, it is hard to evaluate each KPI with pre-defined attributes due to time limitations. Thus, the Focus Group Interviews were held with director-level participants, who were more available in time, while compared with C-level Company Experts.

The main target of Session 3 is to rank and refine KPIs in terms of its Contextual Attributes, which were explained in Chapter 5.4.2. In addition to the assessment of KPIs, participants were also allowed to add, modify or delete any KPI from the KPI-F. These modifications were also recorded by the researcher, and instantaneously reflected in the KPI-F. Table 37 summarizes the methodology of Focus Group Interviews held under Session 3.

During the Focus Group Interviews, the KPI-F was distributed to the participants in which KPIs were listed in y-axis and pre-defined list of attributes in x-axis. Participants were expected to assess attributes through assigning ratings from 1-5 scale for each KPI. For example, "accessibility and measurability" of "net income" is assigned as "four" by the participants as "net income" is a quantitative measure which can be easily analyzed via straightforward financial formulation. Actually, this was not the case in soft measures such as "employee motivation and satisfaction index" as without satisfaction surveys it is hard to measure "employee motivation" quantitatively. Thus, participants preferred to rank "accessibility and measurability" of "employee motivation and satisfaction index" as "two".

Attributes were further aggregated based on their weights, which were defined by participants. They were allocated subjectively based on their relative importance, reflecting the organizations' attitude towards these attributes. Participants preferred to assign equal weights for "simplicity" and "accessibility and measurability" attributes, while they claimed "relevancy and suitability" were the most crucial important as it reflect strategic relevancy of the selected KPIs. In this regard, the weights were assigned as "0,5" for "relevancy and suitability" and "0,25" for both "simplicity" and "accessibility and measurability", sum of which equal to 1.

The ratings of KPI attributes along with the KPI-Framework are given in Appendix 5. After all KPI attributes were assigned, KPIs having the lowest score represented the outliers, which were further omitted in the final KPI list. The KPIs having the highest score were taken as basis in the development of BSC and the Computerized Model.

Table 37: KPI Selection Interviews

Session 3: KPI Selection Interviews	
General Information	
Session Topic	KPI Selection Interviews
Session Type	Focus Group Interviews
Session Targets	• Validate and assess the KPIs based on predefined attributes • Construct the final BSC Structure
Session Duration	2 to 4 hour group interviews with 7 different groups
Participant Composition	
Size and composition	• All focused groups are experienced in their own areas (i.e. HR, Finance, Legal affairs) • Seven focus groups with 2-4 participants attending each. In total 17 participants.
Management Support	No direct support
Pre-Meeting Interviews	Pre-meeting interviews were not scheduled. However, pre-session materials were distributed to the participants one week before the workshop. KPIs were sent previously to the participants in order to make them familiarize with the KPIs for both experience and timeliness purposes of the Focus Group Interviews. However, attributes were not

	provided to the participants in order to avoid initial judgements and biases of the participants.
Session Procedure	
Pre-Session Study	• Identification of KPIs through benchmarking initiatives and literature review • Development of a KPI-F based on SMS • Identification of KPI Attributes representing physical and contextual characteristics
Session Input	• KPI Attributes • KPI Framework
Session Agenda & Methodology	• Overview on the KPI-F • Adding new KPIs or deleting or modifying the wording of existing KPIs • Ranking the KPIs based on predefined attributes
Post-Session Study	Finalizing KPI Framework
Plenary Sessions	Final KPI-F and BSC Structure were not sent for validation, as the final decision about KPI-F and the Model were made in Session 4
Session Output	Balanced Scorecard Structure
Methodology, Tools and Facilitation Aspects	
Tools and Techniques	Group Brainstorming, Ranking with 1-5 Likert Scale
Facilitators and their roles	Researcher was the facilitator. She distributed the structured KPI-F and attributes to the participants. She facilitated in the workshop only when participants asked questions. Compared with other sessions, she directed the session less. Similar to previous sessions, researcher did not add or reject any opinion proposed by participants.
Risks & Limitations	**Risk 13:** Difficulties in understanding some KPIs, especially those that are not utilized previously in the organization **Risk 14:** Difficulties in ranking KPIS in terms of simplicity and measurability, especially when participants are unfamiliar with the associated KPI **Risk 15:** Difficulties in gaining consensus on rankings of KPI attributes **Risk 16:** Difficulties in prioritizing KPIs and selecting the final lis **Risk 17:** Unwillingness of participants to share their opinion, while compared with sessions those held with the top management **Risk 18:** Facing with scope creeps in session due to various questions of participants
Anonymity & Permissions	Participants' names, ideas and votes could be seen and shared by others, in the same focus group interviews. Participants from other focus group interviews could not see rankings of associated BSC perspectives. In both cases, participants could not edit or remove ideas by others. The company allowed to publish assessment and formulation results

5.4.4. Balanced Scorecard Structure

The future scorecard proposed by [2] was revised and adopted in the context of this study. The underlying theory of the adopted BSC Structure is depicted in Figure 8. The traditional BSC developed by Kaplan and Norton represents KPIs of current state

[2]. However, as discussed in Chapter 3, the incorporation of "future thinking" is needed to analyze organizational future performance from today and align both the organizational strategies and processes in accordance.

In the context, the BSC Structure was developed in a way that it contains elements about future state, rather than solely focusing on current state similar to the traditional approaches. It also includes internal and external conditions surrounding the organizations in addition to the KPIs. In other words, the BSC Structure contains three major components for both current and future state; 1) performance indicators, 2) global and market conditions, 3) resources and capabilities, which are described as follows.

1. **Global and Market Conditions:** First element contains global and market conditions to scan the external environment. Probable trends and uncertainties, which have potential to emerge in future, can be elaborated, so that organizations could develop their future strategies based on these trends and uncertainties. This element also encourages the decision makers for adapting "future thinking" which is one of the most crucial capabilities of organizations to survive in dynamic and uncertain environments.

2. **Resource & Capabilities:** Second element is about resources and capabilities of organizations reflecting the conditions of internal environment. Through the incorporation of this element, organizations can understand in what extent they can achieve their strategies with their given current resource and capabilities. In addition, this element is useful to understand their strengths and weaknesses and provides signs about how the organizations should balance their strategies based on their strengths and weaknesses. Through this element, the contribution of implemented current strategic initiatives for the future resources and capabilities can be forecasted. In addition, the impact of future trends and uncertainties towards the organizational resource and capabilities can be elaborated, which provides signs about whether the organizational assets could be adaptable or manage the trends and uncertainties of future.

3. **Performance Indicators:** Final element is about KPIs of organizations, that is the foundation of traditional BSC method. Through these indicators, the practices of strategic implementation can be evaluated and assessed. They provide effective means of translation of current strategy into operational terms. This element also contains probable KPIs those reflect future performance targets of organizations. The theoretical background of this element can be found from Chapter 2 in detail.

Figure 8: Underlying Theory of the Balanced Scorecard Structure

Based on Figure 8, a preliminary BSC Structure was developed by the research by utilizing RC-F, PESTBEL-F and KPI-F. The KPIs, which were evaluated as feasible in Session 3, were taken by the researcher as a basis for preliminary structure. Based on the selected KPIs, factors from RC-F and PESTBEL-F were chosen again by the researcher by maintaining the reasons for the selection. As a pre-sessions study, a preliminary Structure was then finalized in order to review and validate it in Session 4 with Company Experts. The detailed information about Session 4 is given in Table 38.

During the Session 4, experts chose the KPIs from the KPI Framework, which they thought would enable management to provide a sufficient picture of key drivers of the performance. The resulting list of indicators were discussed, refined, simplified and finally agreed upon by experts. As a further effort, they reviewed, added or deleted factors selected from RC-F and PESTBEL-F. The final list of KPIs, RC and PESTBEL factors in the final version of the BSC are given in Table 39. As explained in Chapter 6 in detail, the indicators/ factors given in Table 39 were formulized and modeled in the context of Phase 3 when developing the Computerized Model.

At the end of the first stage, there was an agreement on the content of the BSC. The chosen metrics were found to be adequate to represent the picture of Company performance. One of the Company Expert stated that, these metrics could successfully reveal the 80% of the organization-wide strategy. Experts claimed the chosen KPIs successfully respond to the requirements of different stakeholders, represent both tangible and intangible assets and capitals of the company as well as comprehend diverse operational and business processes.

Table 38: Scorecard Building Workshop

Session 4: Scorecard Building Workshop	
General Information	
Session Topic	Scorecard Building Workshop
Session Type	Group Modeling Workshop
Session Targets	• Shortlisting /simplifying the KPIs in the BSC Structure • Selection of company specific R/C and PESTBEL factors • Development preliminary Causal Strategy Map
Session Duration	5 hours with 1 session break
Participant Size and Composition	
Size and composition	Top Management: 5 C-level managers and 4 directors, 9 participants in total
Management Support	Direct support: Workshop attendance and open conversation
Pre-Meeting Interviews	Pre-meeting interviews were not scheduled. However, BSC Structure was distributed to the participants one week before the workshop day.
Session Procedure	
Pre-Session Study	Development of the preliminary BSC Structure by researcher
Session Input	• Resources & Capabilities • KPI Framework • PESTBEL Framework
Session Agenda & Methodology	• Selecting the KPIs, RC and PESTBEL factors related frameworks • Developing a Conceptual Model (BSC Structure) considering probable relations among KPIs, RC and PESTBEL factors
Post-Session Study	Finalizing KPI Framework
Plenary Sessions	Verbal statements were recorded to maintain opinions of Company Experts as well as utilized when finalizing Conceptual Model as well as developing equations as a post-session study.
Session Output	Balanced Scorecard Structure
Methodology, Tools and Facilitation Aspects	
Tools and Techniques	Group Brainstorming, Individual Causal Mapping
Facilitators and their roles	Researcher was the facilitator. She opened dialogues, directed the session and interactively reflected the opinions of participants on the BSC Structure developed in MS Visio and MS Excel. Researcher did not add or reject any opinion proposed by participants.
Risks & Limitations	**Risk 2.** Reliance on judgements and opinions of dominant participant **Risk 19:** Difficulties in gaining consensus on factors selected and causalities developed in Conceptual Model **Risk 20:** Difficulty in adapting systems thinking and causal mapping
Anonymity & Permissions	Participants' names, ideas and choices could be seen and shared by others. Participants could not reject or remove ideas of other participants. The company allowed publishing assessment and formulation results.

Table 39: Balanced Scorecard Structure

Strategic Objective	Type	Level	Measure (KPIs)	Unit	Method	Polarity	Formula	A	B	C	D
P1. Financial Perspective											
SO2. Maximize Profitability	Lagging	Both	Portfolio Profitability	$	Quan	Max	Portfolio Profitability= total revenue - total expenses	4	4	4	4
	Lagging	BU	Net Profit Margin	%	Quan	Max	Net Profit Margin= Net Income / Net Revenue; Net Income= Total Revenue- Total Expenses Net Profit= (Income) – (Expenses) = (Net Profit)	4	4	4	4
	Lagging	BU	Gross Profit Margin	%	Quan	Max	Gross Profit Margin= Gross Profit / Net Revenue; Gross Profit= Revenue - Cost of Goods Sold Gross Profit= (Revenue) – (COGS) = (Gross Profit)	4	4	4	4
	Leading	BU	Operational Expenses	$	Quan	Min	Cost of goods sold (COGS)	5	3	5	4,5
SO3: Improve Revenue Growth	Lagging	BU	Revenue Growth	%	Quan	Max	Revenue= (Price of Goods) x (Number of Goods Sold) Revenue Growth Rate= ([Current Revenue] – [Past Revenue]) / (Past Revenue) Cumulative Annual Growth Rate (CAGR)	4	4	4	4
P2. Market & Business Growth Perspective											
SO7: Increased Market Share and Competitiveness	Lagging	BU	Tendering performance	%	Quan	Max	# of projects won/ # of entered tender	5	4	4	4,5
SO9: Internationalization	Lagging	BU	Growth rate of International Income	%	Quan	Max	Growth rate of International Income: Revenue growth from previous year	5	4	4	4,5
	Lagging	BU	International Income	%	Quan	Max	Net International Income/ Net Income	5	4	4	4,5

P3: Stakeholder Perspective											
SO10: Improve Client Satisfaction & Loyalty	Lagging	BU	Client Satisfaction Index	Rating	Qual	Max	Customer Satisfaction Index: %g of projects meeting customer expectations	5	4	3	4,25
	Lagging	BU	Client Turnover (Retention) Rate	%	Quan	Min	Customer Turnover (Retention) Rate : number of customers lost/ total number of customers	4	4	4	4
P4: Project Management Perspective											
S013: Increase Cost Management Performance	Lagging	Project	Project Cost Variance	$/ %	Quan	Min	Project Cost Variance = (Actual Project Cost - Budgeted Project Cost)	5	4	4	4,5
	Lagging	BU	Portfolio Cost Variance / Average Cost Variance	$/ %	Quan	Min	Portfolio Cost Variance = (Actual Cost of Portfolio - Budgeted Cost of Portfolio)	5	4	4	4,5
	Lagging	Project	Actual Cost of Work Performed (ACWP)	$	Quan	Based on target	Actual Cost of Work Performed (ACWP): Sum of actual costs of activities that are completed.	4	4	5	4,25
	Lagging	Project	Budgeted Cost of Work Performed (BCWP)	$	Quan	Based on target	Earned Value	4	4	5	4,25
	Lagging	Project	Estimate at Completion (EAC)	$	Quan	Based on target	Estimate at Completion (EAC): Actual cost of work performed (ACWP) + the estimate to complete (ETC) for all of the remaining work.	5	3	3	4
SO14: Increase Time Management Performance	Leading	Project	Project Schedule Variation	hr	Quan	Min	Project Schedule Variation: (Actual Project Duration – Planned Project Duration)	5	4	4	4,5
SO17: Improve Procurement & Supply Chain Performance	Leading	Project	Productivity of purchased/leased machinery and equipment	%	Quan	Max		5	3	3	4
SO18: Improve Site and Resource Management	Leading	Project	Labor Productivity	%	Quan	Max	Efficiency of Direct Labor: Actual labor man-hour/planned man-hour	4	4	5	4,25

P5: Governance and Compliance Perspective											
SO20: Improve Contract and Litigation Management	Lagging	BU	Income from Claims	$	Quan	Max	Income from Claims= # of claims/ earned premium	5	3	4	4,25
P6: Sustainability Perspective											
SO23: Improve Environmental Performance	Leading	Both	Reduction in energy consumption	%	Quan	Max	% reduction in energy consumption= (Initial - Final)/ Initial energy consumption	5	3	3	4
	Leading	Both	Waste Reduction Rate	%	Quan	Max	Waste Reduction Rate: % of construction and demolition waste reduced or recycled	4	3	4	3,75
SO24: Improve Health and Safety Performance	Leading	Project	Fatalities	#	Quan	Min	Fatalities: # of work-related fatalities	5	4	4	4,5
	Leading	Project	Accident Frequency	#	Quan	Min	Accident Frequency: Number of accidents *100 / total number of workers	5	3	4	4,25
SO25: Improve Social Responsibility	Leading	Both	Level of negative impacts on society & local communities	#	Quan	Min	# and extent of negative impacts on society & local communities	5	3	2	3,75
P7: Learning and Growth Pespective											
SO26: Improve Human Capital	Leading	Both	High performing employees	%	Quan	Max	% of high performing employees	5	3	4	4,25
	Leading	Both	Employee Motivation and Satisfaction Index	Ratio	Qual	Max	-	5	3	2	3,75
	Leading	Both	Staff turnover= % of staff leaves / total staff	%	Quan	Min	% staff turnover= % of staff leaves / total staff	3	4	5	3,75
SO27: Improve Technology Capital	Leading	BU	Innovation Pipeline Strength	%	Quan	Max	% of ideas that turned into innovation project	4	3	4	3,75
	Leading	BU	Technology Integration Level	Ratio	Qual	Max	Advantage and integration of IT development, such as ERP, OA, CRM, HRM, SCM	5	2	2	3,5
SO28: Improve Knowledge & Intellectual Capital	Leading	BU	Project Post-Project Review	%	Quan	Max	% of projects with post-project review	4	3	4	3,75

Quan: *Quantitaive,* ***Qual:*** *Qualitative,* ***Max:*** *Maximize,* ***Min:*** *Minimize,* ***A:*** *Relevancy & Suitability,* ***B****: Simplicity,* ***C****: Accessibility & Measurability,* ***D:*** *Overall Rating*

Table 40: Balanced Scorecard Structure (continued)

Resources & Capabilities	Global & Market Conditions
P2. Market & Business Growth Perspective	
R/C: Ability to Make Lowest Bid	G/M: Country Political Stability G/M: Global Demand G/M: National Demand G/M: Strength of National Competitors G/M: Strength of International Competitors G/M: Global Political Stability G/M: Global Economic Growth and Development G/M: Favorability of International Relations G/M: Country Economic Growth and Development
P3. Stakeholder Perspective	
RC: Relations with Major Clients R/C: Relations with Creditors R/C: Corporate Financial Strength R/C: Relations with Media	G/M: Level of Client Expectations G/M: Power of Media G/M: Level of Society Demands GM: Level of Creditor Expectations
P4: Project Management Perspective	
R/C: Relations with Subcontractor/ Suppliers RC: Relations with Designer/ Engineers RC: Communication & Coordination Management Capability RC: Integration Management Capability RC: Scope Management Capability	G/M: Market Availability of Material/ Equipment GM: Competency of Subcontractors/ Suppliers GM: Market Availability of Labor GM: Competency of Designer/ Engineer
P5: Governance and Compliance Perspective	
RC: Performance of Claim/ Dispute Resolution Method RC: Performance of Contract Management System R/C: Relations with Regulatory Bodies R/C: Performance of Risk Management System R/C: Performance of Internal Control and Audit System RC: Relations with Major Clients	GM: Maturity of Laws and Regulations G/M: Strictness of Bureaucracy
P6: Sustainability Perspective	
RC: Performance of H&S training, audit and inspections RC: Performance of H&S management system RC: Performance of environmental training, audit and inspections RC: Performance of environmental management system RC: Compliance to Human Rights, Equal Employment and Diversity RC: Availability of Social Responsibility Initiatives	GM: Strictness of HS Regulations GM: Strictness of Environmental Regulations GM: Strictness of Social Requirements
P7: Learning and Growth Pespective	
R/C: Maturity in Automation and Digitization R/C: Maturity of IT Applications R/C: Organizational Effectiveness R/C: Organizational Learning R/C: Employee Engagement R/C: Maturity of HR Applications R/C: Employee Training	G/M: Advances in Technology G/M: Benefits Provided for Innovation G/M: Advances in Organizational Studies G/M: Availability of Skilled Employee G/M: Industry Reputation G/M: Advances in HR Applications

CHAPTER 6

THE COMPUTERIZED SPM MODEL

This chapter explains the development process of the computerized model. To do so; chapter starts with the explanation of the process on which the computerized model was developed. In the second section of this chapter, model assumptions and boundary conditions, which were necessary to develop a computerized model, are explained in detail. In the third section, the methodology for the development of the computerized model, is described along with the explanation of SD modelling practice with the Stella Architecture tool. In the final section, the stock-flow diagrams developed for each perspective of BSC are explained in detail.

6.1. COMPUTERIZED MODELING PROCESS

As explained in previous chapters, the Computerized Model was constructed based on three major theories; a) dynamic strategy mapping and future BSC proposed by [2], [50], and [76] b) RBV and Dynamic Capabilities proposed by [77] and [78], and 3) SD method proposed by [4]. To construct a Computerized Model in a software environment, firstly a process diagram, given in Figure 9, was developed which shows how measures/factors were quantified and aggregated in the Computerized Model. The process also reflects the strategic management process [53] and strategic thought schools of [86], which were explained in Chapter 4 in detail.

1. **Dynamic Strategy Map and Future BSC:** The SM developed in Computerized Model was constructed based on SOT, as given in Chapter 5. The interdependencies inherit in dynamic SM were examined under three levels;
    1) KPI's or other parameters (i.e. global and market parameters) in BSC perspectives can influence each other.
    2) Global and market parameters representing the external environment can influence manageability of strategic objectives or KPIs associated with these strategic objectives.
    3) RCs representing the internal environment can both control capabilities of the company, manageability of strategic objectives or associated KPIs.

2. **Resource- Based View and Dynamic Capabilities:** RCs are developed in the Computerized Model in line with the definition made by [78]. As proposed by [78], resources are accepted as inputs to the capability development process by accepting that capabilities represent the capacity for a team of resources to perform some task or activity. In this regard, while resources are accepted as

the source of a firm’s capabilities, capabilities are acknowledged as the main source of its competitive advantage [78]. Thus, as explained in forthcoming sections in detail, while capabilities were developed as stock accumulations, resources were represented as in the form of individual conveyor parameters providing inputs to the capabilities. These capabilities highly reflect some strategic objectives explained in Chapter 5, in which the strategic objective itself is to develop and enhance its organizational capability in associated strategic field (i.e. sustainability, governance).

3. **Performance Management Process:** Both the project level- and corporate level strategies and KPIs were developed in a single Computerized Model. In the Computerized Model, it was assumed that, organizational performance is both affected by aggregation of performance of each single project as well as performance of corporate support services. Thus, bipartite effect of projects and support services define the overall performance of organization, which in turn affect future performance of both projects and support services. In other words, the overall organizational performance is also a sign of how well the future projects are managed and be successful. This bi-directional relation among project, shared services and organizational performance are depicted as Performance Flow in Figure 10.

6.2. MODEL ASSUMPTIONS AND BOUNDARY CONDITIONS

In order to computerize the Conceptual Model some model assumptions and boundary conditions were needed. To do so, initial assumptions and boundary conditions were set by the researcher as well as these assumptions and conditions were reviewed, controlled and modified by the Company Experts in the context of Session 5. The underlying methodology of the Session 5 is given in Table 41.

6.2.1. Boundary Conditions

As suggested in the theory of RBV, organizational resources have some attributes such as transferability and replicability. Transferability is one of the key issues in the field of strategic management of different type of project contracts (i.e. projects having JV) or type of organizational revenue sources (i.e. MA, new markets). In cases such as JVs or MA, transferability of resources and capabilities of each party is highly critical for resource allocation and strategic alignment [78]. However, as also discussed with the Company Experts, it was highly difficult to develop and formulize such a model that considers and allocates resources among parties, automatically. Thus, although in real life the Company may enter projects with JV or make some MA initiatives, some boundary conditions were needed to refine type of project contracts or strategic initiatives. In this regard, it was decided with the Company Experts to set boundary conditions for type of business segment, type of revenue growth and type of project contracts. Detailed explanations are as follows;

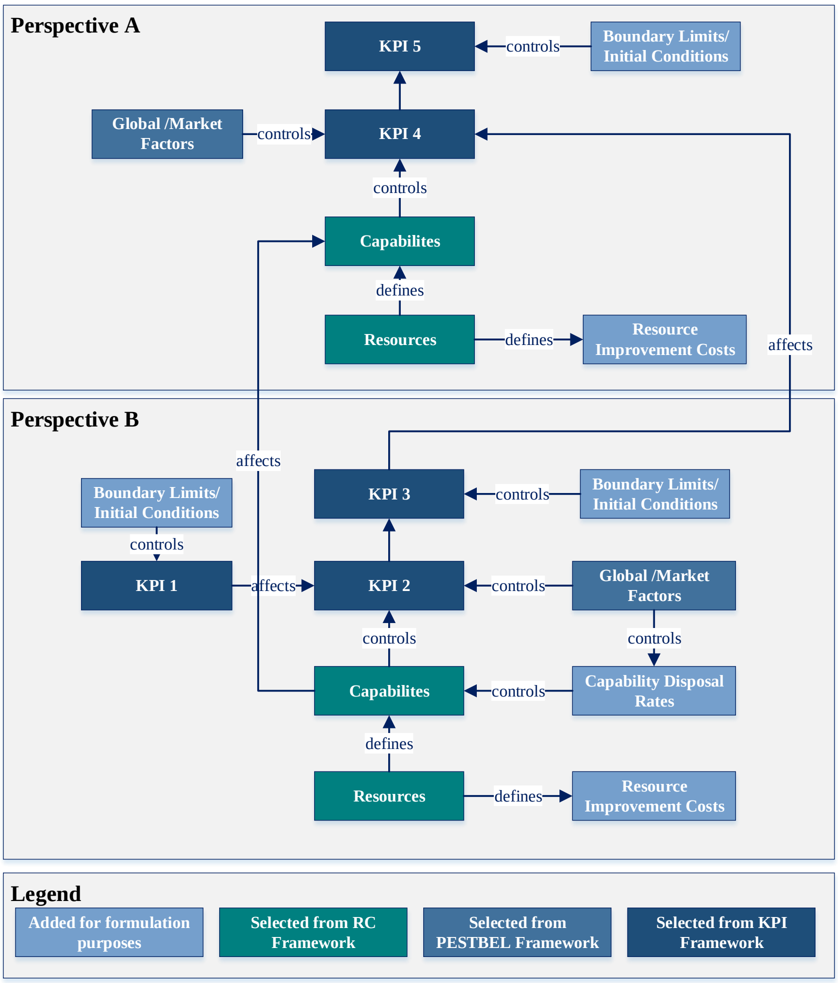


Figure 9: Process Diagram of the Computerized Model

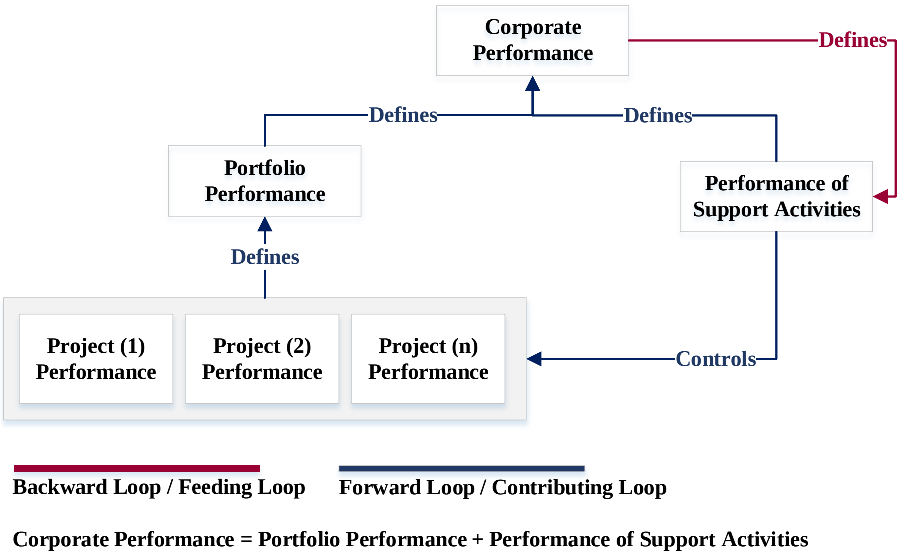


Figure 10: Performance Flow

1. **Type of Business Segment:** To handle complexity and ambiguity inherit in the modelling practice, it was decided with the Company Experts to focus only on construction projects. Thus, both the Conceptual Model and Computerized Model were designed only for contracting activities.

2. **Type of Revenue Growth:** Similar to the strategy literature; the Company gains profit from both organic and inorganic growth. Inorganic growth is about gaining revenue from MA, while organic growth is about revenue gain from company's' own business activity. To overcome the difficulties in "resource transferability" and "complexity" issues, it was decided with the Company Experts to focus solely on organic growth. Thus, the both the Conceptual Model and Computerized Model were designed in a way the Company was supposed to focus only on company's own business activities.

3. **Type of Project Contract:** The Company is currently operating its projects via self-contracting, JVs or partnerships. However, they aimed to focus only on projects those carried out by the Company without any type of partnerships. The preference of the Company about type of project contracts to be modelled, also enabled to overcome difficulties in "resource transferability" and "complexity" issues.

6.2.2. Assumptions about Dynamic Capabilities

DC (1) Stock & Flow Formulations for Resource & Capability Accumulations: The Computerized Model includes some model parameters to reflect dynamic nature of resources and capabilities, as offered in RBV and Dynamic Capabilities Theory [78]. These parameters are 1) yearly improvement rates for resources and capabilities, 2) disposal rates of resources and capabilities, 3) indirect cost of resource and capability improvements.

As described in Figure 9, it is accepted that resources are the sources of organizational capabilities, while these capabilities are the main source of the competitive advantage of the companies [78], which is required for awarding new projects and enhance revenue in turn. Based on this underlying theory, separate stock-flow models were developed in Computerized Model to consider, quantify and use RC accumulations. The assumptions made and formulations developed for the RC accumulations were described via an example from Contract Management Capability, as follows. Capabilities were developed as a "stock" parameter to enable accumulations of capabilities through years.

As given in Figure 9, resources, which influence the accumulation or disposal of the selected capability, was developed as a "conveyor" parameter. These parameters were linked to the capabilities through a "flow" parameter, named "yearly improvement rate", which was developed to reflect the impact of resources on the accumulations of capabilities. In other words, improvement in capabilities was developed as "flow" parameters to reflect the accumulations of capabilities with the improvements in resources through years.

In addition to the yearly improvement rates of the capabilities, capabilities may also dispose or become obsolete due to environmental conditions surrounding the companies. These conditions are referred to as global and market factors, which determines the durability of the capabilities through years [78]. As exemplified by [78], durability of resources varies considerably such that growing pace of technological change will eventually shorten the useful life spans of most capital equipment and technological resources. Based on the discussions of [78], it was accepted in the Computerized Model that, disposal of capabilities was associated with the global and market factors affecting these capabilities. Thus, disposal of capabilities were developed as "flow" parameters to reflect the disposals of capabilities due to changes in the global and market conditions through years.

By representing capabilities in "stock" as well as yearly improvement and disposal rates in "flow" parameters, following equations were formulated for capability accumulations. The Computerized Model of the below equations are given in Figure 11.

Stock Formulation for Capability Accumulation: Contract Management Capability(t) = Contract Management Capability(t - dt) + ("Yearly Imp. of Contract Management Capability" - Disposal of Contract Management) * dt

Yearly Improvement Rate of Capabilities: "Yearly Imp. of Contract Management Capability" = IF (Contract Management Capability<=-5) THEN 0 ELSE (IF(Contract Management Capability + (("RC: Performance of Claim/ Dispute Resolution Method"+ RC: Performance of Contract Management System+ Regulatory Issues Mitigation Performance+ RC: Learning and Growth Capability)/4) <=5) THEN (("RC: Performance of Claim/ Dispute Resolution Method"+ RC: Performance of Contract Management System+ Regulatory Issues Mitigation Performance+ RC: Learning and Growth Capability)/4/"Ave. Actual Project Duration") ELSE (5-Contract Management Capability)/ "Ave. Actual Project Duration")

Yearly Disposal Rate of Capabilities: Disposal of Contract Management = IF (Contract Management Capability>=5) THEN 0 ELSE (IF(Contract Management Capability<=-5) THEN 0 ELSE (IF(Complexity>3) THEN Contract Management Capability*0,2/"Ave. Actual Project Duration" ELSE Contract Management Capability*0,1/"Ave. Actual Project Duration"))

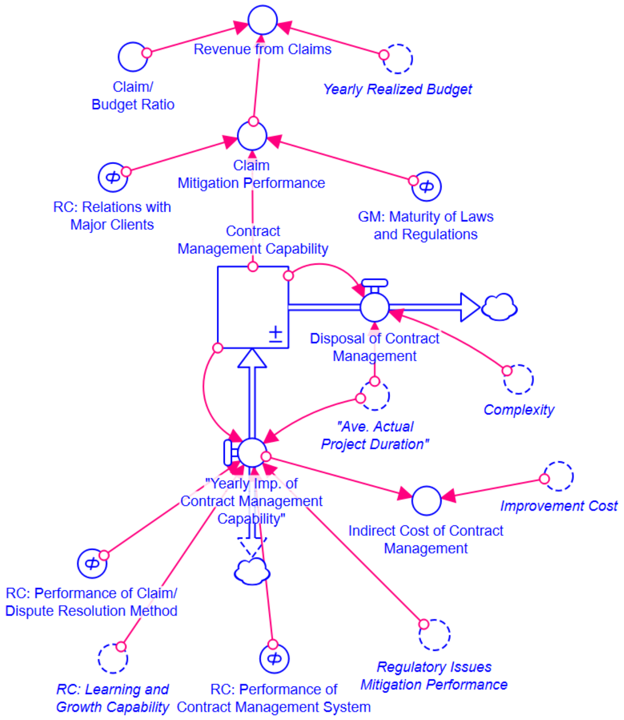


Figure 11: Resource & Capability Accumulations in Strategy Map: An Example from Contract Management Capability

6.2.3. Assumptions about Model Formulation

FA1- Importance Weights of Parameters: The relative importance weights were neglected in model equations by assuming that parameters included in each equation have the same weights. For example, the parameter "Competitiveness" of the Company was formulized by the taking arithmetic average parameters of "Client Satisfaction and Loyalty", "Reputation for Other Stakeholders", "Creditor and Financial Resource Availability" and "Compliance to International Laws and Regulations".

FA2- Rating Conversions: The parameters representing resources, capabilities or global and market conditions were assigned in -5 / 5 rating scale in dimensionless unit. In order to convert both the formulas and units of parameters assigned in -5 / 5 rating scale into some numerical values, a rating conversation was applied. The conversion was made by taking ten times of the assigned rating, then adding "50" to it, and dividing by "100", to obtain a percentage having scale of 0 to 100. For example; in case competitive advantage is so high (i.e. having rating of 5), then the "targeted budget of potential international projects" is the amount same as the targeted budget the company strived for at year 0. However; in case competitive advance is medium having rating of zero, then the targeted budget is half of the initial budget amount the company aimed. Lastly, if competitive advantage is so low having almost -5 rating, then company might not target to award any new projects, despite its initial target. Thus, an arithmetic formulation was developed among competitive advantage and targeted budget of potential international projects. The associated formula is given below. The same rating conversion logic and arithmetic formulation was constructed for the remaining of the model, in similar formulation purposes of diverse parameters.

Targeted Budget of Potential International Projects = "Initial- Targeted Budget International Projects"*((50+ ("R/C: Competitive Advantage"*10))/100)

6.2.4. Assumptions about Model Development

A. Financial Perspective

MA1- Shareholder Revenue: The shareholder revenue gained by the company is the sum of revenue gained from projects and other operating gains by the support services. Project revenue is calculated by the total budget of newly awarded projects multiplied by contract markup. While total budget of newly awarded projects represent the total amount of construction contracts, in other words total amount of money needed to complete the projects, contract markup defines the expected profit gain by the company. Other operating gains are composed of revenue gained from probable claims and innovation practices of the company, which are highly associated with the success of support services in contract management capabilities as well as its technology and innovation capital.

- **Yearly Project Revenue** = (1+(Contract Markup/100))*((Yearly Total Budget of Newly Awarded Projects)+Total Budget of Initial Projects)
- **Yearly Other Operating Gains =** Gains from Claims+ Gains from Innovation
- **Yearly Shareholder Revenue =** Yearly Project Revenue+ Yearly Other Operating Gains

MA2- Contract Markup: Contract markup for the new projects is affected by the contract profit margin and risk-related contingency of the company. Although contract profit margin, which determines the expected profit gain of the company, can be same throughout the years, the risk-related contingency may change based on the changes of how well the company mitigate with its risks. If risk-related contingency is so high due to risks surrounding the company, the contract markup can be high in accordance, which may end up with losing tenders due to higher bid offer compared with other bidders. To be noted that, risk-related contingency is calculated by residual cost overrun risk, calculated in Governance and Compliance Perspective. In addition to the contract markup, the level of contract profit margin is associated with the attractiveness of the market. If market attractive is high, then company may foster higher profit margin, or vice versa. However, in each case, contract profit margin can be value between a pre-defined minimum and maximum limits. Associated formulas are as follows,

- **Contract Markup=** Contract Profit Margin+ "Risk-Related Contingency"
- **Contract Profit Margin=** Min Limit for Contract Profit Margin+ ((50+ (0,5*Attractiveness of National Construction Market+ 0,5*Attractiveness of International Construction Market)*10)*(Max Limit for Contract Profit Margin- Min Limit for Contract Profit Margin)/100)

- **Risk-Related Contingency=** IF (Residual Cost Overrun Risk=1) THEN 0 ELSE (Residual Cost Overrun Risk/50*100)

MA3- Company Expenses: The total expenses made by the company are the sum of its project expenses, general and administrative (G&A) expenses and tax expenses. Project expenses are about total amount of money spent to comply with obligations of the construction contract, which are calculated by the actual cost of the project. Actual cost of the project was calculated by the sum of total budget of projects with the total cost variation. In addition, G&A expenses are about money spent in order to improve capabilities of corporate support services. They include both the capability improvement costs and costs of any defects or incompliances in regulatory or health and safety issues. Finally, tax expenses are about money spent in order to comply with legal and regulatory obligations as well as calculated by the realized budget of the company. Associated formulas are as follows,

- **Yearly Company Expenses =** Yearly G&A Expenses+Yearly Project Expenses+Tax Expense
- **Yearly Project Expenses =** Total Budget of Initial Projects+ (Yearly Total Budget of Newly Awarded Projects)+ (IF (TIME >1) THEN Total Cost Variation/Total Realized Project Duration ELSE 0)

MA4- Profit/Loss: As part of the income statement of the company, profit/ loss was examined as gross profit/loss and net profit/loss.

a. **Gross Profit/Loss:** Gross profit measures the profit after the actual cost of project executions are deducted from project revenue. It measures the profit gained after expenses directly associated with the execution of projects are subtracted from the revenue gained directly from construction operations.
b. **Net Profit/Loss:** Net profit is the remaining profit after the G&A expenses, interests or taxes are deducted from the gross profit/loss. As mentioned previously, G&A expenses include indirect costs needed to improve head office services such as risk and audit management, health and safety management, technology and innovation, and contract management.

- **Yearly Gross Profit =** Yearly Project Revenue – Yearly Project Expenses
- **Yearly Net Profit =** Yearly Shareholder Revenue-Yearly Company Expenses

MA5- Targeted Budget of Newly Awarded Projects: Targeted budget for new projects are affected by the competitiveness level of the company. If the competitiveness of the company is high, it can enter tenders for the new projects, which are large in size and amount. Market attractiveness also affects the targeted budget of newly awarded projects. It was assumed that, if the market is attractive enough, companies could foster for projects having higher budgets. Finally, budgets of existing/initial projects were taken as a baseline for the targeted budgets of new projects. In summary, if competitiveness of the company and attractiveness of the market are so high, company may foster new projects having budgets so higher than its existing projects. Associated formula is as follows,

- **Targeted Budget of Potential National Projects =** Initial Budget of National Projects* ((50+("R/C: Competitive Advantage"*10))/50)*((50+(Attractiveness of National Construction Market*10))/50)

B. Market and Business Growth Perspective:

MA6- Complexity: Complexity of the portfolio is calculated by the number of the ongoing projects divided by the maximum number of projects that could be managed by the company. It was assumed that, there is a maximum amount of ongoing projects the company can execute with its existing resources and capabilities. In case ongoing projects would approach to the manageable number of projects, complexity would increase which in turn influence residual time and cost overrun risk. If the complexity is high, then risk management capability of the company may not be adequate to lower the risk level, remaining residual risk as high. In addition, it was assumed that complexity is also directly related with the unit cost of the improvement of corporate capabilities. Higher complexity may require higher unit cost to improve level of organizational competence. For example; in case company is running a maximum number of projects that it can manage, then more dedicated or specific technological equipment or devices may needed, which requires more investment costs.

MA7- Market Attractiveness: Attractiveness of both national and international market is associated with various global/market parameters of PESTBEL-F. It was assumed that, in case national market conditions are desirable, then company may focus on national market rather than international market, or vice versa. The description of how attractiveness of a market determines the number of targeted projects in related market is given below. The description is given from national market case; however, similar assumptions are also valid for international market.

a. If attractiveness of national market is higher than international market, then company can target manageable maximum number of projects. As will be described in following chapter, after some validation test, it was observed that in extreme cases where national market is so attractive, the targeted number of projects could reach manageable number of projects in the first year. In this case, first year the company would successfully award whole projects that it targets, but as it reaches the manageable number of projects, in second year the company could not award any projects. The excessive changes in the newly awarded projects lead to unrealistic changes in number of employees (such that, in second year nearly all employees will exit) and financial indicators (such that, in first year, net profit is nearly 1 billion dollar but at second year, it is zero). Thus, it was assumed that, in case the company target and win tenders in the manageable amount of project, in order to maintain at the safe side, they target projects that are twice the number of completed projects, only at the first year. However, after the first year, company can target maximum number of projects minus its project completion rate, under the same condition, that is national market is more attractive than international market.

b. If attractiveness of the national market is lower than the international market, then it was assumed that company should maintain its national market presence, but focusing more on the international market. Thus; it was formulated that, if national market is less attractive than the international market, but still attractive in its own, then company should continue to target new projects at the same number of its previously completed national projects.

c. The last case is about unattractiveness of the national market, independent from whether international market is attractive. In this case, it was assumed that, in order to maintain the market presence, the company should target at least the 80% of its previously completed projects in national market.

MA8- Competitive Advantage: Competitive advantage can be directly related to strategy ([5], [77]) or core competences [258]. In RBV literature, competitive advantage is accepted as "an enterprise has a competitive advantage if it is able to create more economic value than the marginal competitors in its product market" [434]. As argued by [53], in this study competitive advantage is associated core competencies and resources, which are the basement of the value creation process of the company as well as reflects how it differs from its competitors. Thus, competitive advantage was formulated with four parameters; a) compliance to international laws and regulations, b) client satisfaction and loyalty, c) reputation, and d) creditor and financial resource availability.

MA9- Newly Awarded Projects: Newly awarded projects were formulated based on the parameters of "ongoing projects", "manageable max number of projects", "strength of competitors", competitive advantage", "targeted number of projects", "project completion rate" and "RC: ability to make lowest bid". The underlying assumption of the formulation is that; if the competitive advantage of the company is high, while the strength of the competitors is low, the company could win the projects it targeted. However, depending on the level of competitive advantage of the company and strength of its competitors, the number of newly awarded projects would eventually decrease.

In addition to the competitive advantage of the company and strength of its competitors, the ability to win new projects is also affected by the extent of the company to make lowest bid. Ability to make lowest bid was calculated by the comparison of the contract markup of the company and market average markup. If company can lower its contract markup compared with market average, then it was assumed that it could increase its ability to make lowest bid.

The description of how competitive advantage, strength of the competitors and ability to make lowest bid will determine the number of newly awarded projects is given below. The description is given from national projects case; however, similar assumptions are also valid for international projects.

a. When the competitive advantage of the company is low and strength of its competitors is high, then company could not win any new projects.

b. If competitive advantage of the company is high while strength of its competitors is also high, then company could win the projects in line with its ability to make lowest bid.
c. If strength of competitors is low while company has high level of competitive advantage, then company can successfully win the projects that it targeted.
d. The given three cases are valid only when ongoing projects of the company is equal or lower than its manageable max number of national projects. As when the number of ongoing projects of the company reaches its maximum number then company could not enter any tenders to award new projects.
e. Thus, a broader if clause is defined which limits the entering new tenders, such that if ongoing projects is equal to manageable number of national projects, then newly awarded projects will be zero independent from the competitive advance of the company and strength of its competitors.

- **Newly Awarded International Projects** = IF((Ongoing International Projects/Year Conversion)<=Manageable Max Number of International Projects) THEN (IF ("R/C: Competitive Advantage"<0 AND "G/M: Strength of International Competitors">"R/C: Competitive Advantage") THEN 0 ELSE ((Targeted Number of International Projects-International Projects Completion Rate)*("R/C: Ability to Make Lowest Bid" +"R/C: Competitive Advantage")/5)) ELSE 0

- **"R/C: Ability to Make Lowest Bid" =** (IF (Contract Markup >=5 AND Contract Markup<="Market Ave. Contract Markup") THEN ("Market Ave. Contract Markup"-Contract Markup) ELSE 5) AND (IF (Contract Markup <=20) AND Contract Markup >"Market Ave. Contract Markup" THEN (Contract Markup-"Market Ave. Contract Markup")/2 ELSE -5)

MA10- Ongoing and Completed Projects: Project completions were calculated based on “Ave. Actual Project Duration”. Associated formulas are as follows,

- **National Projects Completion Rate =** Ongoing National Projects/"Ave. Actual Project Duration"
- **Ongoing National Projects (t) =** Ongoing National Projects(t - dt) + (Newly Awarded National Projects - National Projects Completion Rate) * dt
- **Completed National Projects (t) =** Completed National Projects(t - dt) + (National Projects Completion Rate) * dt

C. Project Management Perspective:

MA11- Project Management Knowledge Areas: The knowledge areas proposed in PMBOK [357] were included in the model. The knowledge areas were incorporated in the following perspectives of the model,

- Project Cost Management, Time Management, Quality Management were included in the Project Management Perspective.

- Project Procurement Management was included in the Project Management Perspective of the BSC Structure as “Supply Chain Management Capability.
- Project Communication and Coordination Management, Project Integration Management, and Project Scope Management were all included in the Project Management Perspective of the BSC Structure as “Communication and Coordination Management Capability”, “Integration Management Capability, and “Scope Management Capability, all of which were assumed to define Managerial Capabilities of the Project Management Organization.
- Project Knowledge Management and Project Human Resource Management were included in the Learning and Growth Perspective of the BSC Structure as “Knowledge and Intellectual Capability” and “Human Capital Capability”, respectively, which were two of the strategic objectives of the Company, defined in SOT. Both the “Knowledge and Intellectual Capability” and “Human Capital Capability” were two of the backbones of the model, as they influence nearly the whole parameters included in the model, either directly, or indirectly.
- Project Cost, Time and Quality Management were included in the model in the form of some set of KPIs. However, the remaining knowledge areas were included as RC parameters, as they were assumed as “leading” indicators. The existence or level of these RC determines the “lagging” indicators of the project management such as cost, time and quality management performance.

MA12- Project Cost Management: Project Cost Management was quantified by Quality Management Performance, Time Management Performance, Client Satisfaction and Loyalty Performance, and overall Learning and Growth Capability of the company, which includes technology, human capital and knowledge management capabilities. Cost Management Performance was utilized when estimating the total earned budget of the company for the work performed. Total cost variation was calculated by subtracting the total realized budget from total earned budget for work performed. Total cost variation is one of the most important parameters in the model, as it also determines the operational expenses made to execute the project. The associated equations are as follows,

- **Total Cost Variation =** Total Realized Budget-Total Earned Budget for Work Performed
- **Total Earned Budget for Work Performed =** IF Cost Management Performance>=3 THEN Total Realized Budget*((50+((Cost Management Performance)*10))/100) ELSE Total Realized Budget*((50+((Cost Management Performance/Residual Cost Overrun Risk)*10))/100)
- **Total Estimated Cost to Complete =** Total Realized Budget-Total Earned Budget for Work Performed +Total Remaining Project Budget
- **Yearly Realized Budget =** Total Remaining Project Budget/"Ave. Planned Project Duration"
- **Total Remaining Project Budget(t) =** Total Remaining Project Budget(t - dt) + (Budget Gain from Newly Awarded Projects - Yearly Realized Budget) * dt
- **Budget Gain from Newly Awarded Projects =** Total Budget of Newly Awarded National Projects +Total Budget of Newly Awarded International Projects

- **Yearly Realized Budget =** Total Remaining Project Budget/"Ave. Planned Project Duration"
- **Cost Overrun (%) =** IF (Total Cost Variation>0) THEN (IF (TIME>1) THEN Total Cost Variation/Total Realized Budget*100 ELSE 0) ELSE 0

MA13- Project Time Management: Project Time Management was quantified by Supply Chain Management Capability, Site Management Capability, and Technical (Design and Engineering) Capability of the Company. Time Management Performance was utilized when estimating the total earned duration of the company for the work performed. It also determines the Cost Management Performance of the company. The associated equations are as follows,

- **Total Earned Duration for Work Performed =** IF Time Management Performance>=3 THEN Total Realized Project Duration*((50+((Time Management Performance)*10))/100) ELSE Total Realized Project Duration* (50+((Time Management Performance/Residual Delay Risk)*10))/100
- **Ave. Actual Project Duration =** ("Ave. Planned Project Duration" +"Ave. Schedule Variation")
- **Ave. Schedule Variation =** Total Realized Project Duration-Total Earned Duration for Work Performed

D. Governance and Compliance Perspective:

MA14- Gains from Claims: In each project claims may rise due to following reasons;

- Additional project scope/ quality requirements requested by the client which is not included in the tender/project budget,
- Acceleration of the project duration upon the request of the client, which in turn requires additional budget to overcome acceleration costs,
- Additional budget needed to cover probable reworks, quality defects, and errors.

The reasons for claim includes, but not limited to the above-mentioned cases. Thus, it was assumed that in each project there would be such reasons which in turn provide additional project income from claims as if the claims are managed properly. In order to formulate the parameter of "revenue from claims", "yearly realized budget", "claim/ budget ratio", and "claim mitigation performance" were utilized. To be noted that; claim/budget ratio was added in order to take total amount of probable claims as an average percentage of the yearly-realized budget. It was expected from the Company Experts to assign a fix percentage for the clam/budget ratio. The associated formula is as follows,

- **Gains from Claims =** Yearly Realized Budget*"Claim/ Budget Ratio"*((50+(Claim Mitigation Performance*10))/100)

MA15- Cost of Regulatory Issues: In each project, regulatory issues may rise due to any non-conformities to a specifications, policies, laws and regulations. Similar to the "revenue from claims", allowable amount of regulatory issues were taken as an average percentage of budget ratio, which are defined by Company Experts in the beginning of simulation practice. Cost of regulatory issues was formulated by “total budget of newly awarded projects”, “regulatory issues/budget ratio”, and “regulatory issues mitigation performance”, described as follows;

- **Cost of Regulatory Issues** = Yearly Total Budget of Newly Awarded Projects* "Regulatory Issues/ Budget Ratio"*((50-(Regulatory Issues Mitigation Performance*10))/100)

MA16- Residual Delay/ Cost Overrun Risk: Residual delay risk and cost overrun risk reflect the remaining risks inherent in project organizations and operations. It was formulated by “risk management capability”, “complexity” and “project time delay or cost overrun risk level”. The underlying assumptions of the formulation are,

- If risk management capability of the company is higher than the complexity born due to the amount of ongoing projects, then company can reduce its risk level in proportion with its risk management capability.
- However; if complexity is so high or larger than risk management capability of the company, then its capability to manage the risks will not be efficient as expected, ending up the residual risk same with the initial risk level. In order words, the company should consider its initial risk level as the residual risk, resulting in low risk tolerance.

The associated formulations for the underlying assumptions for the residual delay and cost overrun risk are as follows,

- **Residual Delay Risk** = IF(Risk Management Capability>=Complexity) THEN (Project Time Delay Risk Level-(((Risk Management Capability-Complexity)/10) *(Project Time Delay Risk Level-1))) ELSE Project Time Delay Risk Level

- **Residual Cost Overrun Risk** = IF(Risk Management Capability>=Complexity) THEN (Project Cost Overrun Risk Level-(((Risk Management Capability-Complexity)/10) *(Project Cost Overrun Risk Level-1))) ELSE Project Cost Overrun Risk Level

Residual cost overrun risk directly affect “total earned budget of work performed” as it was assumed that; if cost management performance of the company is medium or low level, then residual cost overrun risk highly affect earned value from work performed. Such that; if residual cost overrun is so high and cost management performance of the organization is low, then company may not earn any value (that is earned budget for work performed), although it spends money to execute the work (that is total realized budget).

Residual cost overrun risk also have direct effect on “risk-related contingency” in the “contract mark-up”. If residual cost overrun risk very low, then there is no need to any risk-related contingency to the project. However; if residual cost overrun risk so high, then 10% additional contract markup is needed to incorporate risk-related contingency.

In addition to residual cost overrun risk, residual delay risk was utilized when quantifying the “total earned duration for work performed”. Similar to the relation among risk cost overrun risk and cost management performance, residual delay risk affects time management performance of the company. Such that; if residual delay risk is so high and time management performance of the organization is low, then company may not earn any value and have progress on the projects (that is earned duration for work performed), although it spends time to execute the work (that is total realized duration).

E. Sustainability Perspective:

MA17- Cost of Poor Health and Safety: In each project, expenses related with the health and safety issues may rise due to any accidents or fatalities occurred during the execution of projects. It was assumed that, each fatality and accident would end up a cost to the company whose unit costs were defined by Company Experts in the beginning of simulation practice. The cost of poor health and safety was further be included in the G&A expenses of the company. The formulation of the “cost of poor health and safety” is as follows,

- **Cost of Poor Health and Safety =** ((Number of Fatalities*"Ave. Fatality Cost")+(Number of Accidents*"Ave. Accident Cost"))*(Total Ongoing Projects/Year Conversion)

MA18- Number of Fatalities & Accidents: It was assumed that; in each project, accidents or fatalities might occur due to poor health and safety (H&S) management capability or high H&S risks inherent in the projects. They were formulated by “health and safety capability”, “number of accidents” and “average accident/employee ratio”, “average number of blue collar employee/project” and “project H&S risk level”. The underlying assumptions of the formulation are,

- There are an average number of accidents per total number of employees, which were defined by company experts as an input ratio.
- Accidents or fatalities can occur only for blue-collar employees, as they are more prone to H&S risk due to nature of the works.
- Number of accidents was assumed directly proportional with project H&S risk level and adversely proportional with health and safety capability of the company.
- 5% of the accidents can turned into fatalities, in order words fatalities was taken as a fix percentage of the number of accidents.

The associated formulations for the underlying assumptions for the number of fatalities and accidents are as follows,

- **Number of Fatalities =** IF(Health and Safety Capability<0) THEN Number of Accidents*0,05 ELSE 0
- **Number of Accidents =** "Ave. Accident/ Employee Ratio"* "Ave. Number of Blue Collar Employee/ Project"*((50-(Health and Safety Capability* 10))/100)*Project H&S Risk Level

MA19- Level of Negative Sustainability Impacts: It was assumed that, in each project negative environmental or social impacts might occur due to poor environmental management or social responsibility capability of the company. Negative sustainability impacts was formulated by “project environmental risk level”, “environmental capability”, “project social impact risk level” and “social capability”. The underlying assumptions of the formulation are,

- Negative sustainability impacts were elaborated under two folds; a) negative impact from waste, dust, noise production, b) negative impacts to society and local communities.
- Both parameters were assumed directly proportional with project environmental or social risk level and adversely proportional with environmental management or social capability of the company.

The associated formulations for the underlying assumptions are as follows,

- **"Negative Impact from Waste, Dust, Noise Production" =** Project Environmental Risk Level*(-50+(Environmental Capability*10))/100
- **Impacts to Society & Local Communities =** Project Social Impact Risk Level*(-50+ (Social Capability*10))/100

MA20- Reduction in Energy and Water Consumption: It was assumed that, in each project some reductions in energy and water consumptions would be targeted. Reduction in energy and water consumption was formulated by “targeted reduction in energy and water consumption”, “environmental capability, and “strictness of environmental regulations”. The underlying assumptions of the formulation are,

- Targeted reduction in energy and water consumption was directly proportional with the strictness of environmental regulations. The maximum realistic reduction in consumption was assumed as 30%. Thus, in case environmental regulations too strict then company will target 30% reduction in consumption, if regulations are not strict, then the company may not target any reduction.
- In case there is no pressure of environmental regulations, that is they are not strict, the company still target reduction by 5%.
- In what extent the company can realize the reduction is dependent on its environmental capability. In case environmental capability of the company is too high, then it can successfully realize the reduction in the same amount it targeted.

The associated formulations for the underlying assumptions are as follows,

- **Targeted Reduction in Energy and Water Consumption =** 30*(50+(GM: Strictness of Environmental Regulations*10))/100
- **Realized Reduction in Energy and Water Consumption =** Targeted Reduction in Energy and Water Consumption*(50+ (Environmental Capability*10))/100

F. Learning and Growth Perspective:

MA21- Ability to Attract New Employees: It was assumed that, the employee recruitment of the company is dependent on its ability to attract new employees. It was formulated by “global demand”, “strength of international competitors”, “national demand”, and “strength of national competitors”, “competitive advantage”. The underlying assumptions of the formulation are,

- If global demand for construction is medium to high level while strength of international competitors is also high, or if national demand for construction is medium to high level while strength of national competitors are high, then company may not attract new employees with the same of rate of its competitive advantage. In this case, its ability to attract new employees is the proportion of its competitive advantage to strength of its competitors.
- In case, strength of its competitors is not so high, then company can utilize its competitive advantage fully to attract new employees.

The associated formulations for the underlying assumptions are as follows,

- **Ability to Attract New Employees =** IF (("G/M: Global Demand">0 AND "G/M: Strength of International Competitors">0) OR ("G/M: National Demand">0 AND "G/M: Strength of National Competitors">0)) THEN "R/C: Competitive Advantage"/ (("G/M: Strength of International Competitors" +"G/M: Strength of National Competitors")/2) ELSE "R/C: Competitive Advantage"

MA22- Employee Hires and Exists: For employee hires and exists, various parameters were utilized in formulation via diverse assumptions. The parameters used are; “yearly project completion”, “reputation”, “employee turnover”, “average actual project duration”, “number of white collar, blue collar and high skilled employees”, “average number of blue collar and white collar employees/project”, “industry reputation”, “ability to attract new employees”, “total number of newly awarded projects”, and “total ongoing projects”. The underlying assumptions of the formulation are,

- Number of white-collar, blue collar and high skilled employees as well as average number of blue collar and white-collar employees per project are the five major input/ initial values those were defined by the Company Experts. These initials were utilized for each project, independent from the size, complexity and duration of project. Thus, the effect of project attributes on the employee number was ignored.

- Required blue collar employees was simply quantified by total number of newly awarded projects and average number of required blue collar employee per project. It was assumed that the company can hire exactly the same amount of required blue-collar employee, as the budget of blue-collar employee has already included in the project budget, there is no need to allocate additional financial resource for blue-collar employee.
- Blue-collar employees exist when the projects are finished. Thus, number of blue-collar employees was quantified by yearly project completion multiplied by number of blue-collar employees hired for each project. However, it was assumed that, although all the projects executed by the company are finished, still a “minimum number of blue collar employee” would continue to work, in order to maintain these employees for forthcoming projects. Here, “minimum number of blue collar employee” was defined by the Company Experts in the testing session.
- If the total number of newly awarded projects is higher than the total ongoing projects of the company, then the company requires hiring new white-collar employees. The number of new hires was quantified by total number of employees required for the new projects minus the existing number of white-collar employees. If newly awarded projects is lower than the ongoing projects of the company, then company will not hire any additional new employee.
- Company could hire new white-collar employees if skilled employee is available in the market, if the reputation of the industry is high and company is attractive enough to hire new employees. Thus, in what extent the company could hire the required number of employees is quantified through directly proportional with these parameters.
- White-collar employee exists are unavoidable as there can be an employee turnover due to dissatisfaction of employees. Thus, independent from whether the company could win new projects, a number of employee exists is considered directly proportional to the employee turnover.
- In addition to employee turnover, there will be additional exists due to completion of projects. If the number of newly awarded projects is smaller than the total ongoing projects then company will want to make employees exist with the number of completed projects.
- Company can also attract high skilled employees if it has good reputation across the industry. Company aimed to achieve high skilled employee at the 10% of its existing white collar employees, as high skilled employees are beneficial for corporate effectiveness but in the same time they requires higher amount of annual salary compared with other employees.
- High skilled employees can also exist due to dissatisfaction, which lead to employee turnover.

MA23- Innovation Spending and Revenue from Innovation: It was assumed that, company could gain revenue by innovation through either cost cutting or new earnings. However, the company was assumed to allocate some financial source for innovation in order to enhance its innovation capability. In this sense, innovation spending and revenue from innovation were formulated by “technology and innovation capability, “benefits provided for innovation”, and “yearly realized budget”. The underlying assumptions of the formulation are,

- In each project, the company will spend on innovation at a percent of its yearly-realized budget.
- If benefits provided for innovation by government or any other external agencies are high, 1% of its yearly-realized budget is sufficient for the company to spend innovation initiatives.
- If benefits provided are low, then company should invest innovation by its own resources, which were assumed to as 3% of the yearly-realized budget.

The associated formulations for the underlying assumptions are as follows,

- **Gains from Innovation =** IF(Technology & Innovation Capability>0) THEN Innovation Spending*Technology & Innovation Capability ELSE 0
- **Innovation Spending =** IF("G/M: Benefits Provided for Innovation">0) THEN Yearly Realized Budget*0,01 ELSE Yearly Realized Budget*0,03

MA24- Implemented Innovation Initiatives: In each project, company will foster for innovation through some initiatives made by the company employees. The parameters used for implemented innovation initiatives are; “advances in technology” and “technology and innovation capability”. The underlying assumptions of the formulation are;

- If advances in technology in the market are high then the company will target 10 innovation initiatives per year. If the advances in technology are medium level, then company will target eight initiatives, and independent from the advances in the market, company will target at least five initiatives in order to enhance its technology and innovation capability.
- In what extent the company could implement its targets is directly proportional with its technology and innovation capability.

The associated formulations for the underlying assumptions are as follows,

- **Targeted Innovation Initiatives =** IF("G/M: Advances in Technology">=3) THEN 10 ELSE IF("G/M: Advances in Technology">0 AND "G/M: Advances in Technology"<3) THEN 8 ELSE 5
- **Implemented Innovation Initiatives =** Targeted Innovation Initiatives*(50+(Technology & Innovation Capability*10))/100

MA25- Post- Project Appraisals: Knowledge management is one of the strategic objectives of the company. As a knowledge management approach, the company fosters for conducting post-project appraisals in order to capture, classify, store, retrieve and reuse the gained lessons learned throughout the projects. In each project, the company is aimed to conduct these appraisals, however it was assumed that in what extent the company could conduct them in real life is dependent on it knowledge and intellectual capability. Thus, the number of post-project appraisals was quantified by multiplying of total completed projects to knowledge and intellectual capability. The associated formulations for the underlying assumptions are as follows;

- **"Number of Post-Project Appraisals"** = Total Completed Projects*(50+(Knowledge & Intellectual Capability*10))/100

The summary of the model assumptions are given in Appendix 7.

Table 41: Model Assumptions Workshop

Session 5: Model Assumptions Workshop	
General Information	
Session Topic	Model Assumptions Workshop
Session Type	Group Modeling Workshop
Session Targets	• Validation of initial model assumptions • Identification of model boundary conditions • Identification of initial values for the parameters
Session Duration	5 hours with 1 session break
Participant Composition	
Size and composition	Top Management: 5 C-level managers
Management Support	Direct support: Workshop attendance and open conversation
Pre-Meeting Interviews	Pre-meeting training sessions were scheduled to introduce the concept of system dynamics. These trainings were provided to each participant separately. Training took 0.5 hours to 1 hour depending on the interest of experts towards system dynamics concept. During the trainings, firstly theoretical background of the systems thinking and dynamics introduced briefly, and then a simplified model, pre-developed in Stella Architecture, was exemplified to managers to introduce the software. In addition, the list of Model Assumptions was distributed to the participants one week before the workshop day.
Session Procedure	
Pre-Session Study	Development of the initial model assumptions and boundary conditions by researcher
Session Input	• Model Assumptions List • Model Parameters List
Session Agenda & Methodology	• Reviewing each model assumption • Discussing the model assumptions separately within the workshop • Assigning initial values for the parameters
Post-Session Study	• Finalizing model assumptions
Plenary Sessions	Verbal statements were recorded to maintain opinions of Company Experts as well as utilized when finalizing Model assumptions and developing equations as a post-session study.
Session Output	• Final Model Assumptions List • Initial Values for the Parameters
Methodology, Tools and Facilitation Aspects	

Tools and Techniques	Group Brainstorming
Facilitators and their roles	Researcher was the facilitator. She opened dialogues, directed the session and interactively reflected the opinions of participants. Researcher did not add or reject any opinion proposed by participants.
Risks & Limitations	**Risk 2.** Reliance on judgements and opinions of dominant participant **Risk 21:** Difficulties in gaining consensus on the model assumptions **Risk 22:** Rejecting the idea of assuming something, and claiming to have objective roots for each assumption **Risk 23:** Expecting from the Computerized Model to solve everything **Risk 24:** Difficulties in adapting "systems thinking", difficulties in understanding model formulations and "Stella Architecture", despite the training session **Risk 25:** Difficulties in assigning initial values, especially those that require subjective judgements
Anonymity & Permissions	Participants' names, ideas and choices could be seen and shared by others. Participants could not reject or remove ideas of other participants. Although the company allowed publishing assessment and formulation results, they did not permit to give real/ original initial values directly as they reflect the real financial, human resources and other data. Thus, some manipulations were made in original values; however, the underlying theory and simulation results were remained same.

6.3. METHODOLOGY FOR THE DEVELOPMENT OF THE COMPUTERIZED MODEL

The Computerized Model was developed by using the Model Window (MW) and results were presented in Interface Window (IW) in Stella Architecture. The Model Window was used for the construction and computerization of the model. It consists of some set of tools to create SFDs and provide the computational equations for them. It supports tables, graphs, and numeric displays as output objects built into the model for viewing and analyzing model behavior. However, MW was mainly facilitated for development of the Computerized Model, and IW for presenting and experimenting the Model. IW supports a variety of input objects, including knobs and sliders, and a variety of output objects, including tables and graphs. IW was used in three ways; 1) to built Data Entry Interface for assigning input values for the model parameters, 2) to build Results Interface for representing outputs generated after simulations in tablular form, 3) to build Dashboard Interface for visualizing and comparing key outputs in graphical form.

Steps undertaken for building and experimenting the Computerized Model in the MW are,

1. **Developing Stocks and Flows**: Based on the Process Diagram of the Computerized Model, firstly the parameters, which were built in the form of stocks and flows, were decided by the researcher. They constituted the main chains of the model and were central to the system to portray. Flows were selected for the parameters, those having a year dimension, such as yearly operating income.

However, stocks represented the accumulations of these parameters, such as total operating income. The detailed background information of stocks and flows are given in Chapter 5. To be noted that; the development process of the Computerized Model was an iterative task, as after adding a new parameter to the Model, its fit and interaction with other parameters should be elaborated. Dimensional (unit) consistency should be ensured after adding each parameter as well as equations should be re-constructed as additional parameters might be connected. For example, each flow into or out of a stock must use the same unit of measure or all stocks in a main chain must use the same unit of measure.

2. **Adding Converters:** isee Company defined the purpose of converters into two folds; first modification flows by defining how quickly or slowly a flow is moving, and second converting units of measures from one variable to another in other to make them compatible to each other. In the Computerized Model, the converters were built for both purposes. First, parameters of RC-F and PESTBEL-F were defined in the form of converters as they define the level of flow, which is about modification of flows. Second, a converter named "Year Conversion" was added in order to convert units and make units of related parameters consistent.

3. **Adding Connectors:** After stocks, flows and converters were built as separate parameters in the Model, the associated interrelations among them were built through connectors. The connectors were developed in line with the original SMS developed in Chapter 6. In order to make feedback loops in the model clear, polarity to connectors were assigned either as positive (represented as +) or negative (represented as -). Stella Architecture also provided to mark loops as either balancing ("-" or "B") or reinforcing ("+" or "R") by placing a text box in the loop. However, to simplify the visual representation of the Computerized Model, these text boxes were not built on the model. Nevertheless, assigning polarity allowed to visually representing cause-and-effect relationships between model parameters.

4. **Defining Model Equations and Boundary Conditions:** After connectors were built, model equations were defined for the stocks, flows and converters in the model by using Built-in functions of the tool. The whole list of the model equations were also exported from the tool via Equation Viewer. The initial values for stocks were built as separate converters and stocks equations were defined by utilizing initial converters. In order to overcome the subjective judgements of the researcher, the initial values for stocks were remained for Company Experts to be defined as converter parameters. Some constants or boundary conditions were also defined in some model equations. Again, for mitigation of subjectivity, these constants or boundary conditions were recorded as Model Assumptions by the researcher in order to ask for Company Experts in Session 5. In addition, boundary conditions were tested for adequacy by utilizing Simulation Event Dialog Box.

    a. **Built-ins:** Built-ins allow to easily incorporating functions into model equations. They are organized into the following categories in Stella Architecture; 1) array built-ins, 2) cycle-time built-ins, 3) data built-ins, 4) delay built-ins,, 5) discrete built-ins 6) financial built-ins, 7) logical built-ins, 8) mathematical built-ins, 9) miscellaneous built-ins, 10) simulation built-ins, 11) statistical built-ins, 12) test input built-ins, and 13) trigonometric built-ins. In the Computerized Model, "data built-ins", "logical built-ins", and "mathematical built-ins" were facilitated when developing model equations.

b. **Simulation Event:** Simulation Event dialog box enables to specify the triggers for different events that can occur during a simulation, and the actions to be performed when the event occurs. In the Computerized Model, the Simulation Event Dialog was utilized as a control mechanism for boundary conditions, through some pre-defined thresholds in Simulation Event Dialog. Thresholds specify the value that the variable must exceed, or drop less, than for an event to occur. In this regard; especially for R/C and PESTBEL parameters, the scale of -5 to 5 was defined as thresholds in the Simulation Event Dialog as well as events were defined as stopping the simulation run and giving an error message about the run. As explained in Chapter 8, when variables, for which thresholders were defined, would have a value larger than or the drops below the threshold, then event (stopping the run) would be triggered. The Simulation Event Dialog was utilized in Boundary Adequacy Testing, which is described in Chapter 8, in detail.

c. **Equation Viewer:** Equation Viewer enables to see all model equations organized according to options selected in the dialog (i.e. in alphabetical order, in section order). The Equation Viewer was utilized to import the model equations in an excel form in order to cross check diverse model assumptions inherent in these equations. Model equations given in Appendix 8 also exported from Equation Viewer function of the Stella Architecture.

5. **Assigning and Checking Units:** After model equations were built, units were assigned to each model parameter. To do this, firstly the availability of the units needed in the model was checked in the Unit Editor. Then, units for each parameter were added through also checking "suggest units" option of the Stella Architecture. In order to ensure dimensional consistency, the left and right-hand sides of equations should have consistent units; in order words, converters should satisfy dimensional consistency with flows and flows with the stocks. Dimensional consistency was also tested in Dimensional Consistency Test, undertaken in the context of Step 18. The tool enables an automatic dimensional test, which allows quickly finding and correcting any inconsistencies that might arise. The findings of this test are given in Chapter 8.

6. **Developing the Visualization Model in IW:** The Computerized Model developed in the Model Window in Stella Architecture, was also completely build in Interface Window for both visualization and experimentation purposes. In other words, while Computerization step of the SDP was undertaken in Model Window, the

Testing and Simulation steps were carried out in Interface Window. The presentation modes of the Computerized Model were developed in Interface Window after the main model was finished in Model Window. To do so; all model parameters constructed in each perspective were presented in either input or output views separately in Interface Window. Input parameters were built in the form of "slider", "knob" or "numeric input" in the Interface, which were expected to select by the model users during the simulation and experimentation process. With the defined inputs, the results of the model run were also build in related pages of the Interface. Thus, output parameters were presented in "table", "graph" or "gauge" diagrams to show the results of the model run. The Interface also enabled the representation of results of diverse scenarios for given parameter into a single graph, allowing comparison of results in terms of scenario inputs. The screenshots taken from the Computerized Model in the form of Data Entry, Result and Dashboard Interfaces are depicted in Appendix 10 along with the example from the Baseline Testing.

a. **Interfaces:** Building an interface allows sharing model with others, especially those who do not have the experience to work with models in Stella's model building environment. As mentioned by isee Company, interfaces can range from relatively simple exploration environments, allowing the user to change one or two things and see the results, to rich interactive experiences to discover multiple levels of interaction.

7. **Running the Model Simulation:** After the Computerized Model was built in MW, the model is ready for simulation. To start the simulation, firstly simulation length and unit of time were specified by using Run Specs Dialog Box. The tool also allows running the model separately for different modules or sectors. In other words, modelers can choose to run the entire model, including all sectors and modules, or to run only selected modules and/or selected sectors. The Computerized Model was developed as a single module and seven sections representing seven perspectives of the BSC Structure, separately. During the development of the Computerized Model of each perspective under different sections, some preliminary model simulations were conducted by running the model only for the newly developed perspectives (sectors). However, these runs did not regarded as model simulations as they were only conducted for preliminary tests for development purposes. After the whole model was built, the model was run in 5 years simulation time, including all sectors. The Stella Architecture tool also give warnings and do not start to the run process if,
   - All the model variables were not fully defined with equations,
   - There exists any variable that was connected to another variable, but not included in its equation,
   - There exists any missing variable that was defined in the equation of another variable, but not connected to it,
   - Initial values for stock variables were not defined,
   - There exists any boundary adequacy error whose rule was defined in Simulation Event Dialog Box,
   - There exist any dimensional inconsistencies.

a. **Simulation Unit and Length:** The time for run was selected years (other options are hours, days, weeks, months, etc.) and length of the simulation was defined based on the simulation unit. The simulation unit was selected as years, and simulation length as taken as 5 years by the Company Experts in Session 5. To be noted that; length of the simulation can also vary depending on the selected unit, for example; 24 hours, 30 days, 12 months, 4 quarters, 10 years, etc.

b. **Data Manager:** Data Manager enables to save model runs for use later on, to reorder runs, to load parameters from earlier runs and to load runs from external data sources. In the Computerized Model, the Data Manager was facilitated to save the model runs for Baseline, Scenario 1, 2 and 3 in order to retrieve, reuse and compare the model runs for all four cases.

c. **Integration Method:** The tool utilized standard numerical integration methods to solve the model equations when the model is run. These standard integration methods are; 1) Euler's method, 2) Cycle-time method and 3) 4th-order Runge-Kutta. In the Computerized Model, Euler Method was selected as the numerical integration method for the model run.

8. **Conducting Sensitivity Analysis or Optimization:** The Stella Architecture tool also allows conducting optimization and sensitivity analysis, which are additional features of the tool. Sensitivity analysis provides to change constants or initial values over multiple runs, with which results of the change can be seen in comparative graphs or tables. Optimization lets to identify parameter(s) that provide the best results toward achieving a target outcome.

6.4. DEVELOPMENT OF THE STOCK-FLOW DIAGRAMS OF THE MODEL

In total, 269 parameters were defined in the model. The distribution of these parameters based on their associated perspective, conceptual type, computerized type and units assigned to them are given in from Table 42 to Table 44. The equations, with which each parameter was formulated, are given in Appendix 8. As explained in Chapter 6.2, underlying assumptions of each equations are also given in Appendix 8.

Table 42: Distribution of Model Parameters/ Conceptual Model Type

Perspectives	Formulation	GM	Initial	KPI	RC	Total
Financial	16		6	11		33
Governance and Compliance	13	2	7	6	6	34
Learning and Growth	28	6	14	14	7	69
Market and Business Growth	15	9	5	4	1	34
Project Management	12	4	4	14	5	39
Stakeholder	6	4	3	6	3	22
Sustainability	12	3	9	8	6	38
Total	**102**	**28**	**48**	**63**	**28**	**269**

Table 43: Distribution of Model Parameters/ Computerized Model Type

Perspectives	Converter	Flow	Stock	Total
Financial	13	12	8	33
Governance and Compliance	25	6	3	34
Learning and Growth	51	12	6	69
Market and Business Growth	26	4	4	34
Project Management	27	6	6	39
Stakeholder	13	6	3	22
Sustainability	29	6	3	38
Total	**184**	**52**	**33**	**269**

Table 44: Distribution of Model Parameters/ Units Assigned

Units	# of Units Assigned
1/Year	26
Accidents/Employees	1
Dimensionless	134
Employees	8
Employees*USD	3
Employees/Projects	4
Employees/Years	10
Number	2
Projects	10
Projects/Years	11
USD	19
USD/Accidents	2
USD/Years	29
Years	6
USD/ Projects	4
Grand Total	**269**

Table 45: Distribution of Model Parameters/ Conceptual and Computerized Model Type

Model Type	Converter	Flow	Stock	Total
Formulation	47	46	9	102
GM	28			28
Initial	48			48
KPI	33	6	24	63
RC	28			28
Total	**184**	**52**	**33**	**269**

The SFD of each perspective are given in from Figure 12 to Figure 18. The parameters defined within the model along with their attributes are also given in Appendix 6.

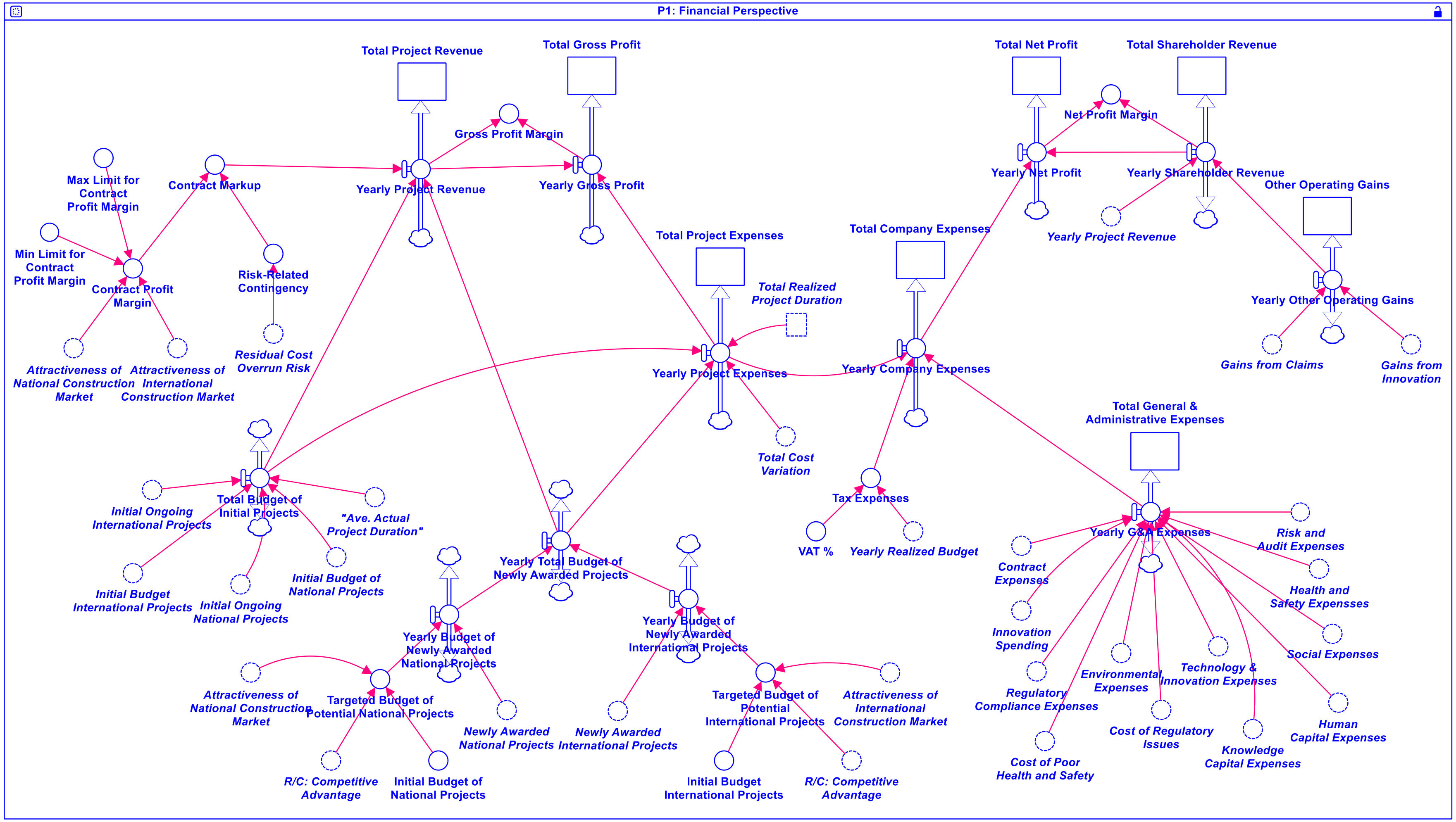


Figure 12: Stock Flow Diagram of the Financial Perspective

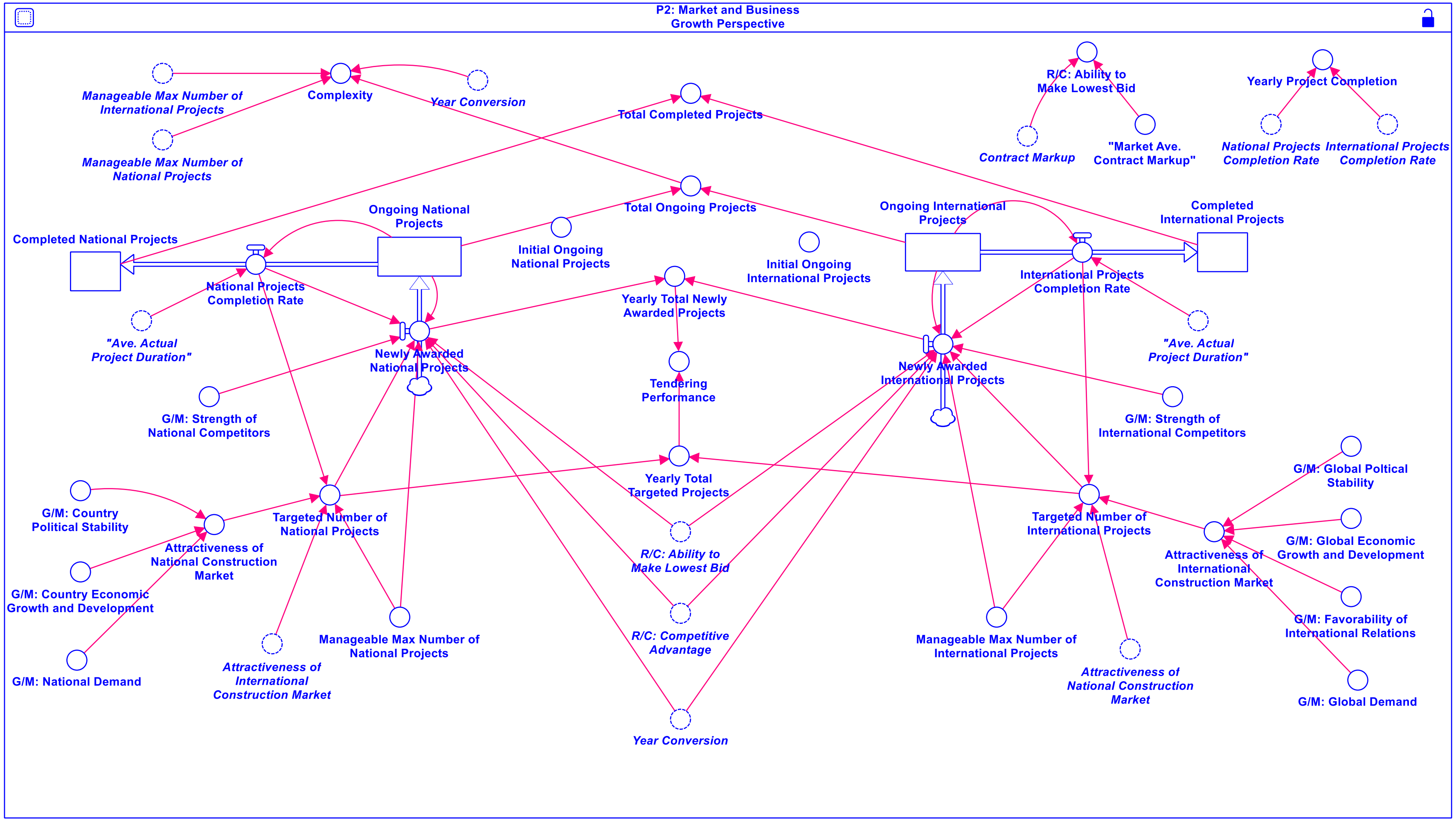


Figure 13: Stock Flow Diagram of the Market and Business Growth Perspective

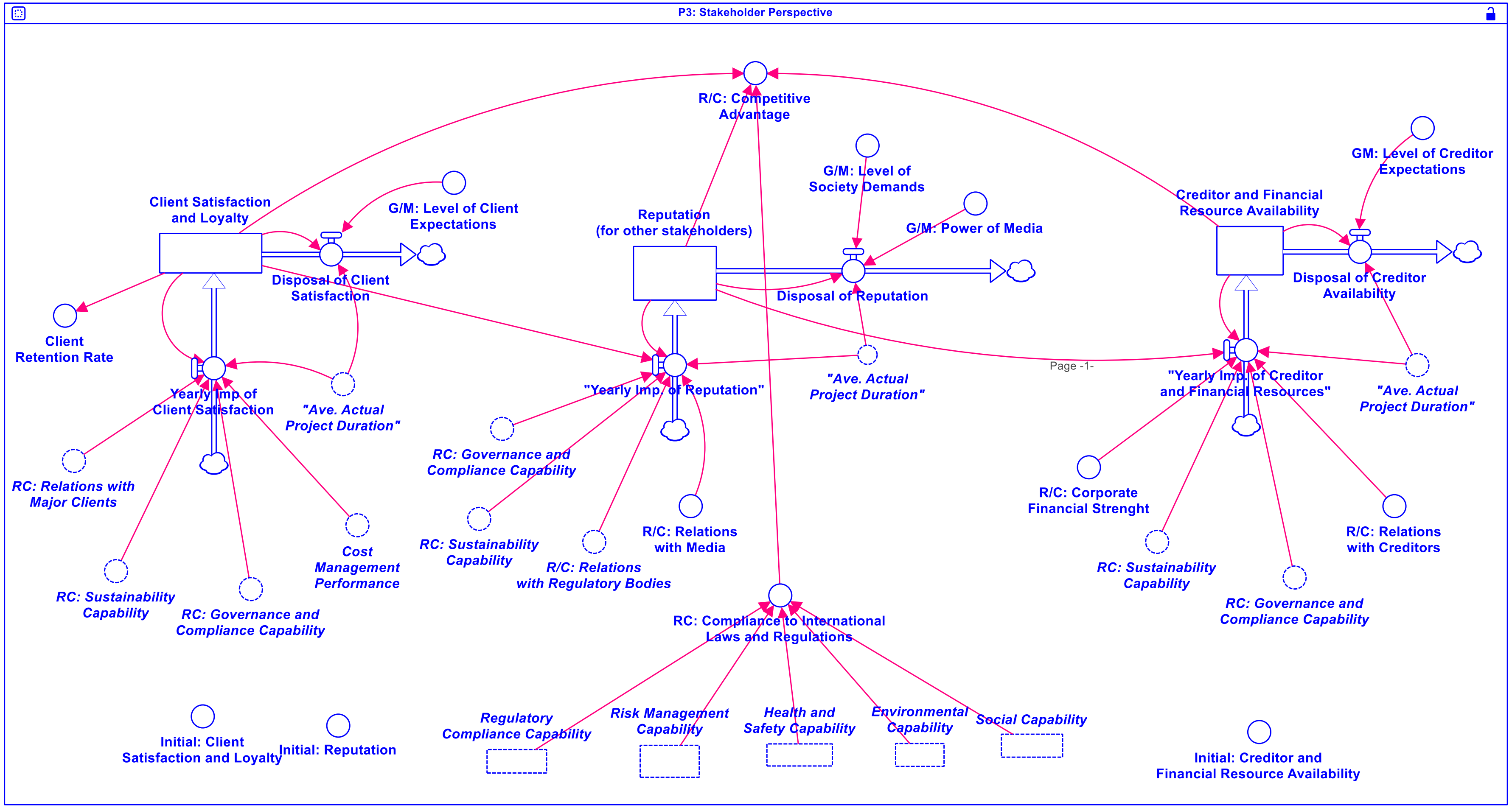


Figure 14: Stock Flow Diagram of the Stakeholder Perspective

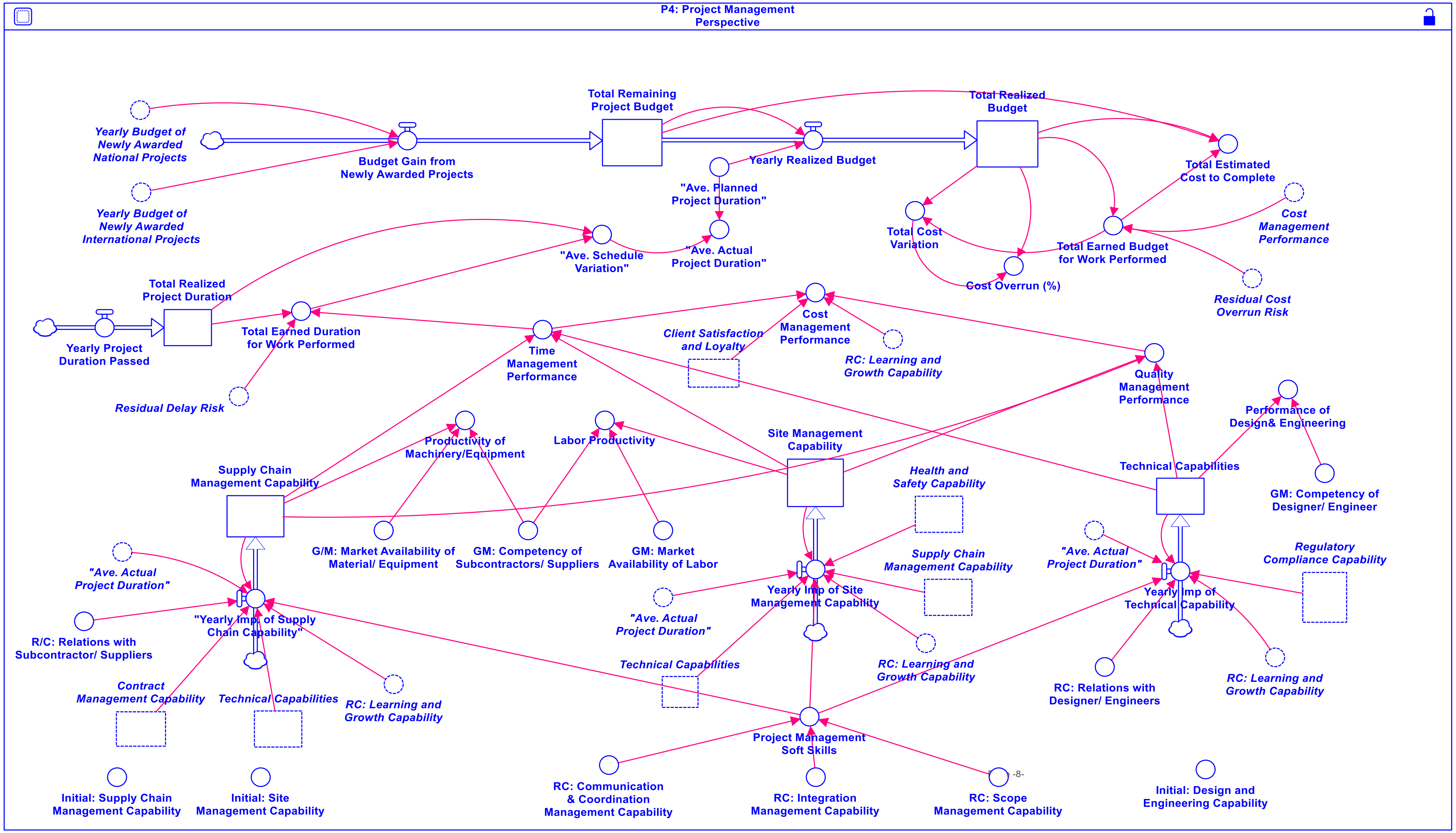


Figure 15: Stock Flow Diagram of the Project Management Perspective

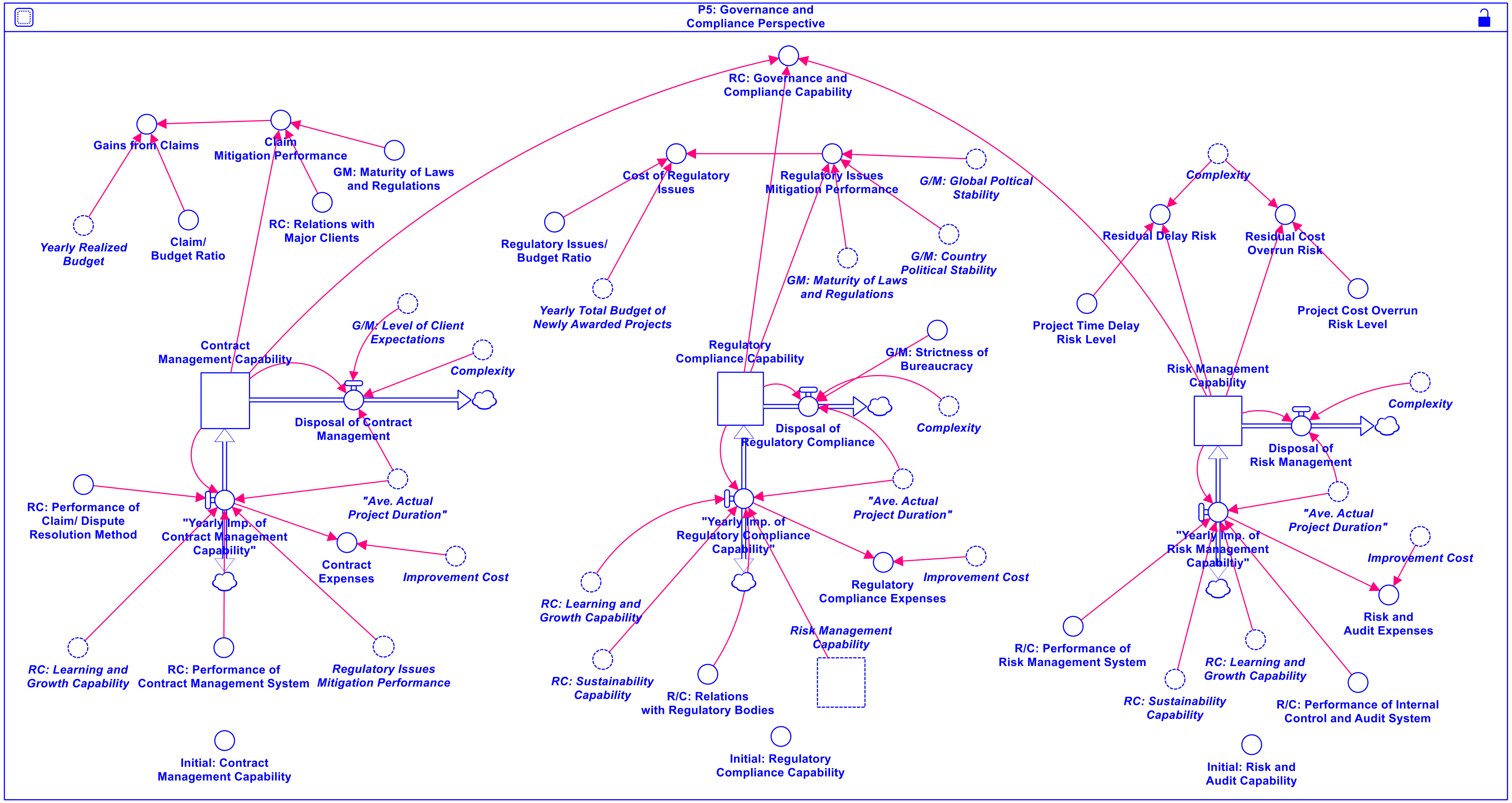


Figure 16: Stock Flow Diagram of the Governance and Compliance Perspective

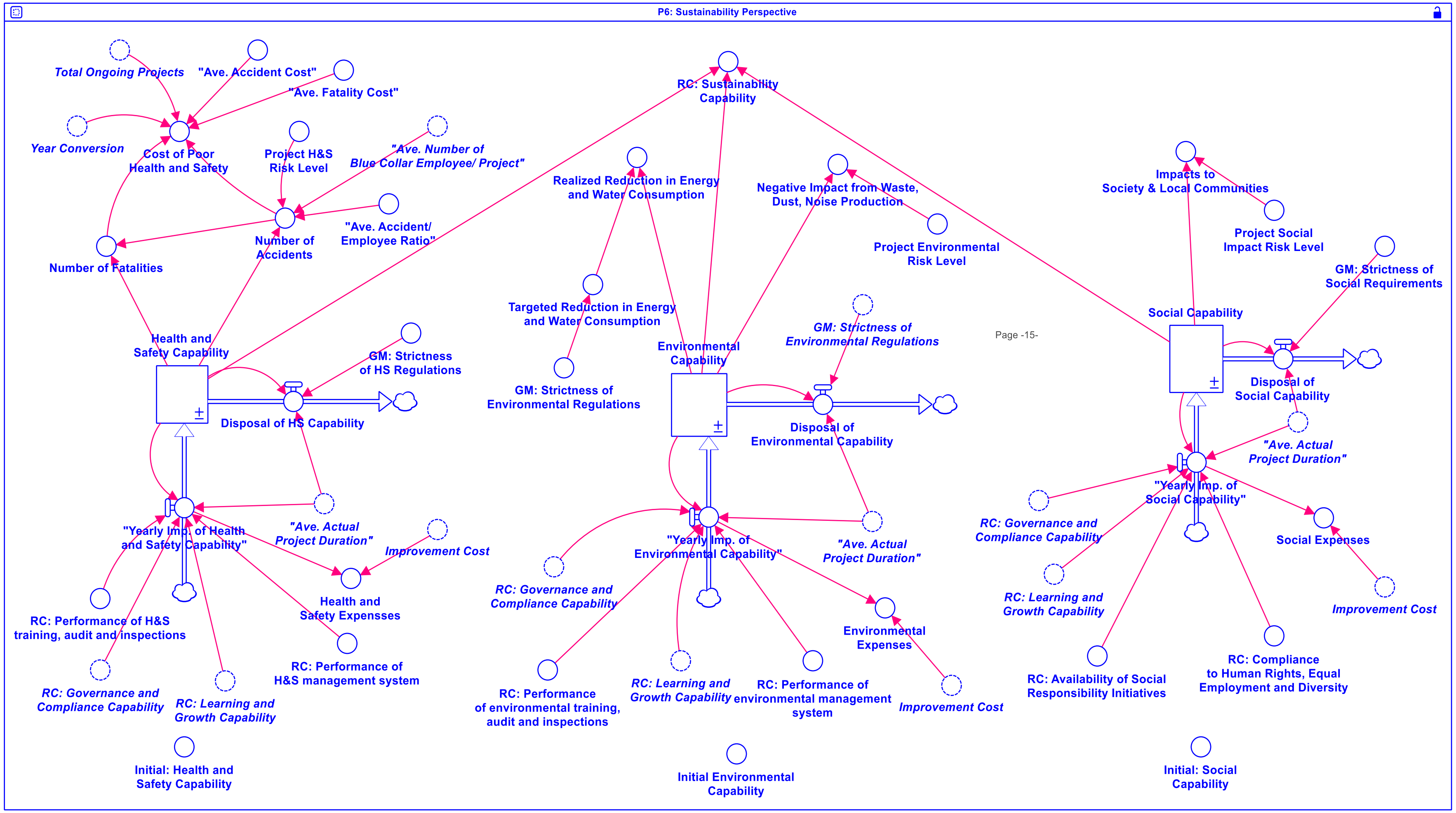
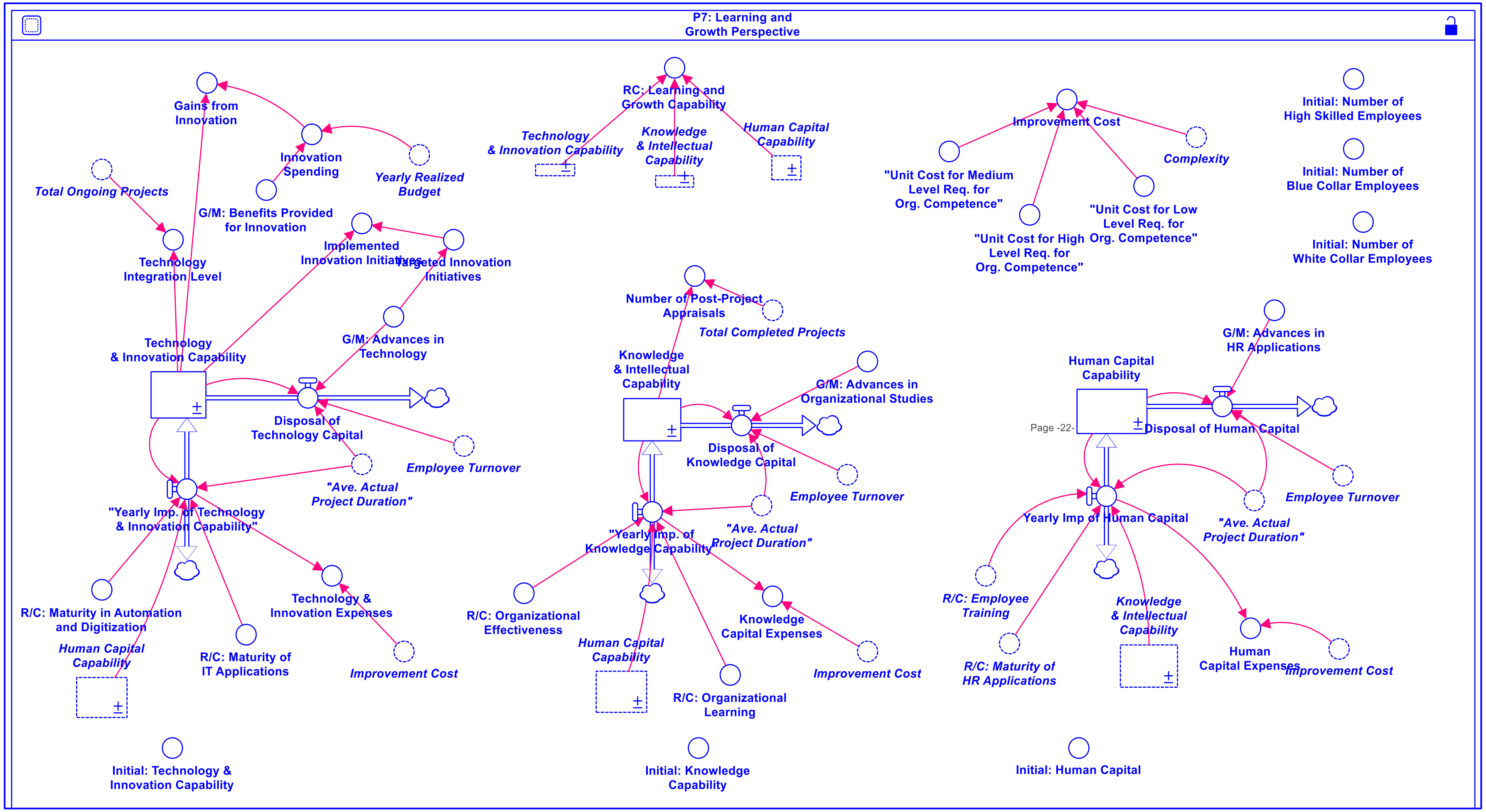


Figure 17: Stock Flow Diagram of the Sustainability Perspective



P7: Learning and
Growth Perspective
Gains from
Innovation
Innovation
Spending
Yearly Realized
Budget
Total Ongoing Projects
G/M: Benefits Provided
for Innovation
Technology
Integration Level
Implemented
Innovation Initiatives
Targeted Innovation
Initiatives
G/M: Advances in
Technology
Technology
& Innovation Capability
Disposal of
Technology Capital
Employee Turnover
"Ave. Actual
Project Duration"
"Yearly Imp. of Technology
& Innovation Capability"
R/C: Maturity in Automation
and Digitization
Human Capital
Capability
R/C: Maturity of
IT Applications
Technology &
Innovation Expenses
Improvement Cost
Initial: Technology &
Innovation Capability
RC: Learning and
Growth Capability
Technology
& Innovation Capability
Knowledge
& Intellectual
Capability
Human Capital
Capability
Number of Post-Project
Appraisals
Total Completed Projects
Knowledge
& Intellectual
Capability
G/M: Advances in
Organizational Studies
Disposal of
Knowledge Capital
Employee Turnover
"Ave. Actual
Project Duration"
"Yearly Imp. of
Knowledge Capability"
R/C: Organizational
Effectiveness
Human Capital
Capability
Knowledge
Capital Expenses
Improvement Cost
R/C: Organizational
Learning
Initial: Knowledge
Capability
Improvement Cost
Complexity
"Unit Cost for Medium
Level Req. for
Org. Competence"
"Unit Cost for Low
Level Req. for
Org. Competence"
"Unit Cost for High
Level Req. for
Org. Competence"
Initial: Number of
High Skilled Employees
Initial: Number of
Blue Collar Employees
Initial: Number of
White Collar Employees
G/M: Advances in
HR Applications
Human Capital
Capability
Page -22-
Disposal of Human Capital
Employee Turnover
"Ave. Actual
Project Duration"
Yearly Imp of Human Capital
R/C: Employee
Training
Knowledge
& Intellectual
Capability
R/C: Maturity of
HR Applications
Human
Capital Expenses
Improvement Cost
Initial: Human Capital

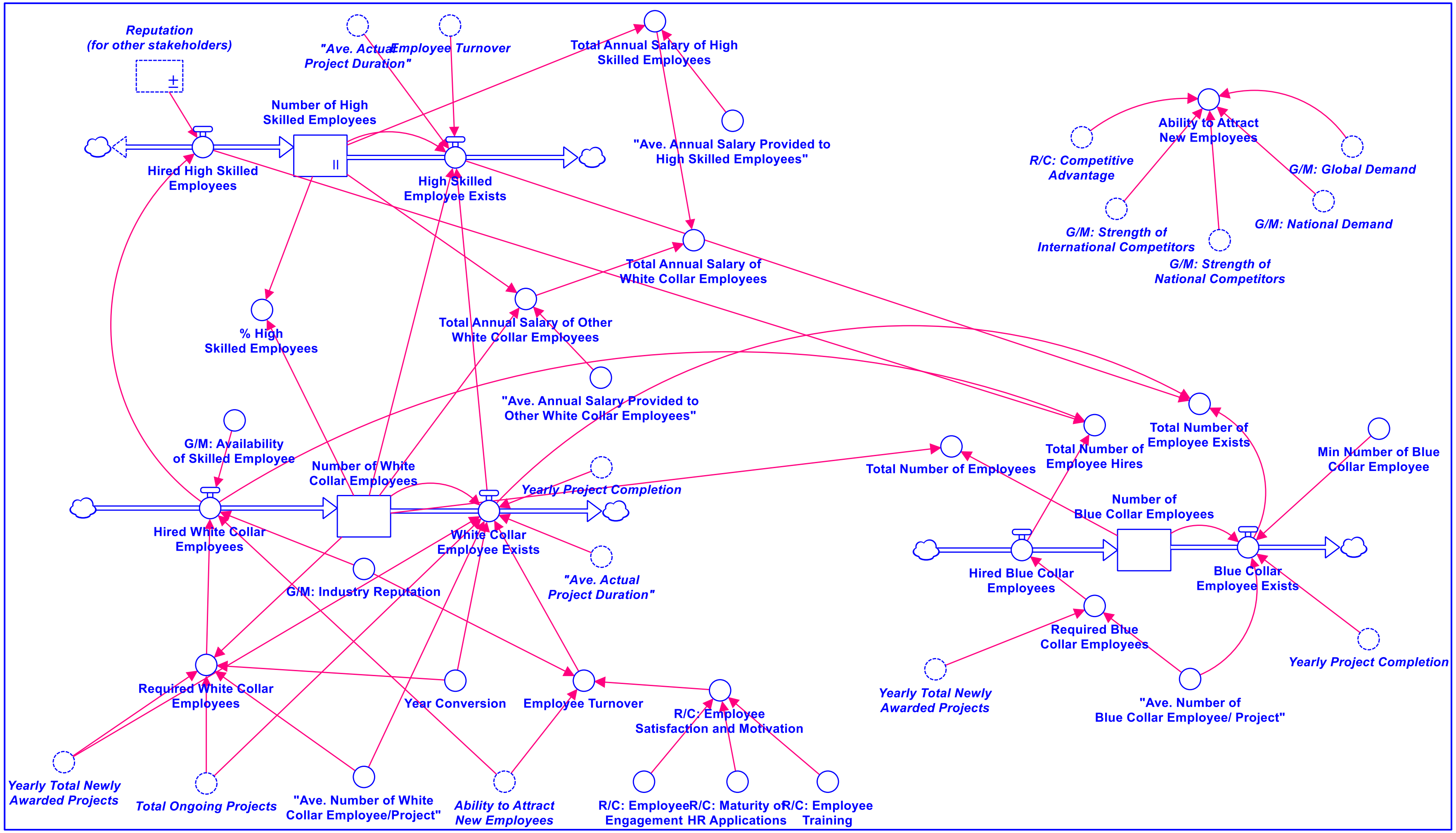


Figure 18: Stock Flow Diagram of the Learning and Growth Perspective

CHAPTER 7

MODEL VERIFICATION AND VALIDATION

This chapter explains the methodology and findings of model verification and validation step of the SDP. To do so; firstly a brief theoretical background on validation of SD models is given as well as some structured methods of validation are explained. In the second section of this chapter, model verification and validation methodology undertaken in this research, is explained. In this context, model validation is examined under three groups; conceptual model validation, computerized model verification, and operational validation. These tests aim to ensure both the structural and the behavioral validity of the final model. This chapter also explains methodology of each test and findings obtained.

7.1. THEORETICAL BACKGROUND ON VALIDATION

Foundations of the model validation were laid by Jay Forrester, who introduced SD concept in his book, Urban Dynamics [3]. He "laid great emphasis on validation, posing the question of whether there are objective and uncontroversial tests that a model is properly constituted" [435]. With the evolution of SD, various studies are conducted to develop methodologies on verification and validation SD-based models.

As exemplified in Table 46, numerous definitions for model verification and validation are proposed in current literature. Although the terminologies employed in these definitions differ in some context, their contextual backgrounds reveal that there is a consensus on overall purpose of verification and validation in SD modelling. In addition to the concept of "verification" and "validation", some authors also announced other attributes for SD models such as "credibility", "generality" and "accreditation" [305].

In this study, a broader definition suggested by [436] was followed. According to [436], model validation is "the process by which we establish sufficient confidence in a model to be prepared to use it for some particular purpose". As introduced in the forthcoming sections, model validation process has two aspects; a) validation, which means "ensuring that the model's structure and assumptions meet the purpose for which it is intended", b) verification which is about "ensuring that its equations are technically correct" [435].

Table 46: Definition of SD Model Verification and Validation

Definition	Source
Model Verification	
Testing if the computer program of the computerized model and its implementations are correct.	[304]
Testing a seemingly correct model by its authors in order to find and fix modeling errors.	[437]
The process of ascertaining if the implementation of the model (the computer program) represents precisely the concept of authors' description and specification.	[438]
Ensuring that the computer program of the computerized model and its implementation are correct	[439]
Model Validation	
Proving that within its application domain the computerized model has a satisfying level of accuracy, which is in keeping with its intended use.	[304]
An overview and assessment of the model operation performed by its authors and by experts in the field in order to find out if the model with a satisfying level of accuracy represents the real system.	[437]
The process of deciding on the assessment method as well as the very assessment of the level to which the model (its data) represents the real world from the perspective of its intended use.	[438]
Substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model	[439]
The process of determining that the model on which the simulation is based on an acceptably accurate representation of reality	[440]
The process of establishing confidence in the usefulness of a model	[436]
The process of determining the degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model	[441]
Identification and quantification of the error and uncertainty in the conceptual/ simulation models, quantification of the numerical error in the computational solution, estimation of the simulation uncertainty, and finally, comparison between the computational results and the actual data.	[442]
Model Credibility	
Model credibility is concerned with developing in (potential) users the confidence they require in order to use a model and in the information derived from that model.	[305]
Model Accreditation	
Model accreditation determines if a model satisfies specified model accreditation criteria according to a specified process. A related topic is model credibility.	[305]

[436] elaborated validation from pragmatic point of view that “there are almost endless opportunities for making mistakes in any kind of model building”. [79] suggested that a model is built for a purpose and its validity is fundamentally determined by the extent to which it fulfills that purpose. Authors put great emphasis on model boundary such that “the boundary between what has been included and what has not is a significant determinant of the model’s validity.”

Similar to the [79], [443] also argued that “validation” should be about whether a model is “suitable for its purpose and … consistent with the slice of reality which it tries to capture”. That argument also enforces the two fundamental assumptions of SD modeling process; (1) SD models are built to fulfill a purpose, and (2) structure of the model drives its behavior [3]. This view of [3] on model validation has also widely shared by other modelers and policy scientists such as [444], [445], [79], [442], and [446]. They agreed upon the two key issues in validation. First validation should explore whether the model is acceptable for its intended use (i.e. does the model mimic the real world well enough for its stated purpose) ([3], [447], [79], [448]). Second, it should reflect how much confidence to place in model based inferences about the real system ([449], [308], [450], [67], [442]).

In this regard, ensuring “right behavior for the right reasons” becomes the core of the SD modeling validation process [308]. Validation deals with the assessment of the comparison between ‘sufficiently accurate’ computational results from the simulation and the actual/ hypothetical data from the system [442]. “In fact, how well a simulation model represents the actual system is at the core of validation process of any type of simulation model ([451], [442]). Thus, since no model can claim absolute truth and cannot have absolute validity, the best that can be hoped for is that the model be suitable for its purpose and consistent with reality ([452], [446]).

Model validity is also evaluated in terms of a model's suitability and consistency by asking the questions of “whether the model suitable for its purposes and the problem it addresses" and "whether the model consistent with the slice of reality it tries to capture" [443]. [453] pointed out verification; validation and credibility are the three criteria for the evaluation of whether a simulation is an accurate representation of the actual system considered. [436] discussed validation in detail throughout his book. He defined model validity as “well-suited to its purpose and soundly constructed” based on his philosophy of “the model should do the same things as the real system and for the same reasons”. Based on the criteria proposed in [436] and [79], he also proposed 15 general criteria for assessing the quality of a model.

“Failing a test helps to reject a wrong hypothesis, but passing is no guarantee that the model is valid” [446]. Authors added that, rejecting a model because it fails to reproduce an exact replica of past data or it fails to predict a specific future event is not acceptable “because social systems operate in wide noise frequencies” [446].

In addition, it is often too costly and time consuming to determine that a model is valid over the complete domain of its intended applicability. Instead, tests and evaluations are conducted until sufficient confidence is obtained that a model can be considered valid for its intended application [303]. The consensus is that validating SD models should imply a continuous cycle of confidence building tests throughout the iterative development of a model [452]. It is also very essential that to conduct model verification and validation tests in parallel to the development of a model, rather than testing the model after the model completion. It means that evaluation of the model should be an iterative procedure conducted during all phases of the simulation modeling" ([454], [303]).

"There is no single test which serves to 'validate' a system dynamics model. Rather, confidence in a SD model accumulates gradually as the model passes more tests and as new points of correspondence between the model and empirical reality are identified" ([79], [446]). [67] also argued "validation and verification are impossible; the emphasis should be more on model testing i.e. the process to build confidence that a model is appropriate for the purpose".

Another concern is that how much the model output could deviate from system output and remain valid [455]. Since the model created approximates the actual system, some errors are unavoidable. Model validation thus resides in decision between the modeler and client; when both groups are satisfied, the model is considered valid [456]. [446]). It is also criticized that, the modeler (or researcher) cannot carry out validation alone; communication with the client (or user) plays a large role in building a valid model and establishing its credibility [437], [446]. In addition, involvement of stakeholders in the modeling process results in the increased credibility of the model ([455], [445]).

"The validation of a SD model is, thus, not a simple matter of subjecting a model to some standard set of classic statistical tests" [452]. As argued by [446], there can be no one test, with which the model validity can be judged. [457] and [80] gave an insight on validation of simulation models using statistical techniques and reasoned that the technique applied would depend on the availability of data in the real system. [446]. "System Dynamics models have certain characteristics that render standard statistical tests inappropriate." [308]. "This does not mean that the validation process for a SD model should be solely qualitative. It means that a "SD modeler needs to employ tests, both quantitative and qualitative, that can serve to evaluate a given model." [452].

The studies on SD validation has also elaborated and argued various attributes of validation process such as time allotted to the validation tests, number of tests, data used for the tests, test documentation, stakeholders of the validation process or required level of confidence to accept the model. In summary, of those who do elaborate validation in detail there is a broad measure of agreement on,

- There is no such thing as absolute validity,
- Only a degree of confidence which becomes greater as more and more tests are passed;
- Some tests are so significant that they can be regarded as mandatory,
- Dimensional consistency being a sine qua non ([435], [79], [436], [458]).

[80] proposed some statistical techniques for assessing the quality of fit between a SD model and historical data. [308] and [459] developed "the idea that SD validation is

rooted in a relativist rather than an absolutist point of view". He demonstrated that structurally oriented behavior test, originally suggested by [79] as a behavior validity test, can detect major structural flaws of the model despite the fact that model can generate highly accurate behavior patterns. He also added the so-called Turing test can be helpful to understand the probable differences among model-generated outputs and real historical behavior of a system.

Various other authors have conducted structural and behavioral validity tests to ensure their SD model are suitable with their purpose and credible enough to rely on. Nearly all authors aforementioned utilized Boundary Adequacy Test, Structure Verification Test, Dimensional Consistency Test, Parameter Verification Test and Extreme Conditions Test to test structural validity of their models.

The tests utilized for the behavioral validity, are generally varied based on intended purpose or use of the model, availability of model data, required level of confidence of the model. Numerous qualitative tests are offered in current literature to test behavioral validity; such as behavior reproduction test, behavior prognosis test, behavior anomaly test, generic behavior test, extreme policy test, border adequacy test and behavior sensibility test. Some authors ([80], [308]) also suggested statistics-based test to compare model-generated data with the historical data to ascertain behavior validity. Some of these statistical tests are; Mean Square Error (MSE) and Root Mean Square Error Percentage (RMSEP) (i.e. [442]), normality tests and the one-way ANOVA test (i.e. [460] and [461]) or the Theil inequality statistics.

In their consecutive studies ([445], [442], [462]), Qudrat- Ullah and its colleagues utilized some statistical tests to ensure behavioral validity of their SD type simulation model developed for exploring energy policy. These tests are; Structurally- Oriented Behavior Test, Mean Square Error (MSE), Root Mean Square Error Percentage (RMSEP). [463] used Behavior Verification Test, and Sensitivity test to validate their SD model which was developed for environmental performance simulation of construction waste reduction management in China. [461] facilitated one-way ANOVA test for behavioral validity of their SD model, utilized when investigating carbon-footprint reduction of public transportation in United States. [464] used Behavior Sensitivity and Validity test for their SD model developed for socio-hydrological model for agricultural wastewater reuse at the watershed scale.

7.2. MODEL VALIDATION METHODOLOGY

A systematic validation methodology is needed to verify and validate the Computerized Model in an organized and efficient manner. After the examination of available validation methods offered in literature, methods recommended by [79], [80], [67] and [442], were taken as basis for the model validation. As suggested by the authors, model validation was elaborated in the context of structure of model, its behavior and its implications of the user's policy. In this regard, a Model Validation Methodology was developed, which defines goals, strategies and test undertaken in validation process. As depicted in Figure 19, Model Validation Methodology was constructed in a way that it also represents Research Design given in Chapter 3.

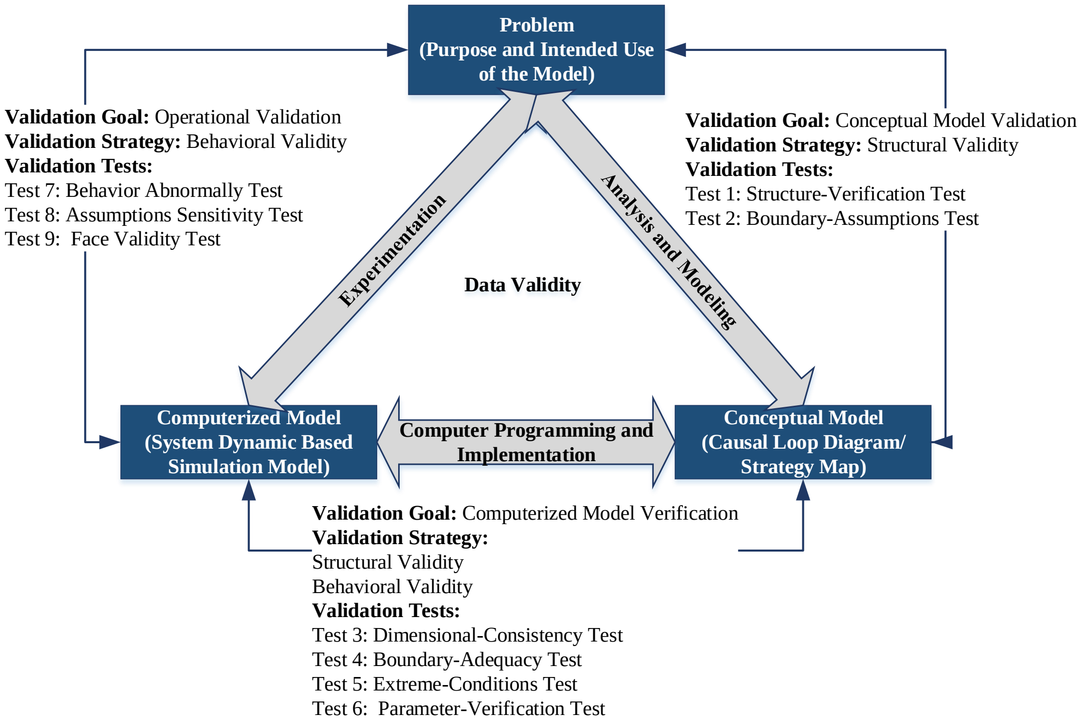


Figure 19: Model Validation Methodology

Based on the Model Validation Methodology, it was aimed to test the validity of problem itself, the Conceptual Model and the Computerized Model through some iterative tests. These tests were oriented towards the exploration of structural validity and behavioral validity to ensure whether the model was constructed properly as well as behavior generated by the model was intended for its purpose and mimic real world behavior. The terminology given in Figure 19, are explained as follows,

- **Conceptual Model Validation:** Conceptual Model validation is about whether the theories and assumptions underlying the Conceptual Model are correct and whether the Conceptual Model reasonably represents the problem entity, and fulfills its intended purpose ([453], [442], [303]. A credible conceptual model is a prerequisite to any validation endeavor. If causal relations or parameters in a Conceptual Model were wrong, then Computerized Model generating outputs would simply be misleading or incorrect ([308], [444], [462]). Thus, "rights structures for the right behavior", was at the core of the validation process, which required identification of the appropriate causal structures and logical formulations [308].

- **Computerized Model Verification:** 'Computerized model verification' is about testing that the implemented model accurately represents the conceptual description of the model ([453], [442], [303]. It ensures whether the underlying assumptions and formulations of the developed model can accurately portray the intended purpose.

- **Operational Validation:** ‘Operational validation’ is about confirming that output behavior of the Computerized Model accurately and sufficiently portray the intended purpose over the domain of the model’s intended applicability [305]. In other words, it elaborates whether the model adequately represents the real system. It also determines the credibility of the models [442].

- **Data Validity:** ‘Data validity’ is about testing whether the data required for model development, evaluation, testing and experimentation are adequate and accurate ([465], [453], [442], [303]).

- **Structural Validity:** Structural validity is about ensuring whether the developed model reasonably and adequately represents the purpose of the model, the phenomenon that is simulated and real life situations being modeled ([464], [461]). In this sense, they are utilized to compare the structures of the SD model and real system in order to ensure every relationships between elements of the real system can sufficiently be described by mathematical equations of relationships between corresponding elements of the SD model ([79], [454]).

- **Behavioral Validity:** Behavior validity is about ensuring whether the simulated behavior can produce observed behavior or anticipated trends of the real system ([313], [462], [308], [448], [464]). It defines whether the "behavior of the model matches the behavior of the real system, and here the relationship between the structure and the model behavior is analyzed with particular care.” ([79], [454]). While structural validity ensures whether the model is developed correctly or working properly, behavioral validity ensures whether the model exhibits the same behavior as the real world behavior.

To carry out the Model Validation Methodology in a systematic procedure, a Model Validation Process was also developed based on the works of [304], [454] and [466]. As given in Table 47, Model Validation Process was constructed to reflect the sequence of each validation test offered in Model Validation Methodology given in Figure 19.

Table 47: Verification and Validation Process for SD Model

Process	Studies Conducted
1. Development of the basic model	As explained in Chapter 5 and 6 respectively, the model was developed first as a Conceptual Model and then transformed into a Computerized Model via Stella Architecture.
2. Reaching an agreement about model between the model development team, model sponsors and users	As explained in Chapter 6, an agreement about the Conceptual Model was made with the Company Experts during Session 4.
3. Specify the validation approach and a minimum set of specific validation techniques to be used in the validation process	As explained in Chapter 7, the validation techniques were selected by the researcher based on the available literature.
4. Test the assumptions and theories underlying the simulation model	As explained in Chapter 6, model assumptions were discussed and validated by Company Experts in Session 5.
5. Validate the Conceptual Model through iterative Structural Validity Tests, perform at least Face Validity on the Conceptual Model	As explained in Chapter 5, the Conceptual Model was developed and validated by Company Experts through serial sessions. The findings of these sessions provided a basis for 1) Structure Verification Test and 2) Boundary Adequacy Test. During Face Validity Test, questions about Conceptual Model were also asked.
6. If Conceptual Model complies with the system problem and purpose, test the Computerized Model through iterative structural and behavioral validity test. Re-conduct aforementioned validations tests for the new version of the model.	As explained in Chapter 7, the Computerized Model was validated through 1) Parameter-Verification Tests, 2) Dimensional- Consistency Test, 3) Boundary- Adequacy Test and 4) Extreme- Conditions Test.
7. If Computerized Model complies with the system problem and purpose as well as successfully convert Conceptual Model into mathematically formulated model, test the operational validity through behavioral validity test.	As explained in Chapter 7, the operational validity is validated through three tests; 1) Behavior Abnormally, 2) Assumptions Sensitivity Test and 2) Face Validity Tests. Face validity test is conducted with the Company Experts during Session 6.

8. If these tests are not giving satisfactory results or if the users (Company Experts) reach the conclusion that it is necessary to expand the model with new feedbacks, step two is repeated and the whole procedure is continued	As explained in Chapter 7, tests were conducted iteratively until model is ensured to fulfil its intended purpose.
9. If the results of the aforementioned tests are satisfying, and the modeler concludes that the model is complete	As explained in Chapter 7, at the end of Face Validity Test (Session 6), Company Experts agreed that the model is satisfying.
10. Develop validation documentation for inclusion in the simulation model documentation.	As explained in Chapter 7, findings after each test were recorded and documented throughout the validation process. Indeed, modifications made after each test were also recorded by the researcher, as given in Appendix 9.
11. If the simulation model is to be used over a period of time, develop a schedule for periodic review of the model's validity.	Not applicable in this study.

7.3. MODEL VALIDATION TESTS

As depicted in Figure 19, a serial structural and behavior validity tests were conducted to ensure behavioral, structural and operational Validity. To ensure structural validity four tests were carried out, 1) Structure Verification Test, 2) Boundary Assumptions Test, 3) Dimensional Consistency Test and 4) Boundary Adequacy Test. In addition, for behavioral validity four other tests were undertaken, 1) Extreme Conditions Test, 2) Parameter Verification Test, 3) Behavior Abnormally Test, and 4) Assumptions Sensitivity Testing. In addition to these tests, a separate Face Validity Test was also conducted to capture judgement and opinions of the Company Experts on the validation process, itself.

The list of all verification and validation tests is given in Table 48. In total 17 tests were conducted with having various trials and runs made in the model by using Stella Architecture tool. The model passed these tests either requiring some modifications in the model or not. After making modifications in the model, tests, which the model has passed previously, were re-conducted to ensure the model was still valid under these test.

The process diagram of the tests is depicted Figure 20 to reflect the sequence of the tests performed. The process itself also revealed the iterative nature of the validation process to enhance the robustness and reliability of the SD model. Solid lines in Figure 20 represent first trials of each test, while dashed ones reflect secondary or iterative tests made after each model modification.

Table 48: List of Verification and Validation Tests

List of Verification & Validation Test				
Test ID	**Test Type**	**Trial ID**	**Number of Runs**	**Final Test**
1	**Structure-Verification Test**	n/a	n/a	n/a
2	**Boundary-Assumptions Test**	n/a	n/a	n/a
3	**Parameter-Verification Test**	n/a	n/a	n/a
4	**Dimensional Consistency Test**	n/a	n/a	Passed after modifications
5	**Boundary-Adequacy Test**	Trial 1-Trial 10	185 runs	Passed after modifications
6	**Behavior- Abnormally Test**	Trial 1-Trial 8	52 runs	Passed after modifications
7	**Boundary-Adequacy Test**	Trial 11	25 runs	Passed after modifications
8	**Extreme-Conditions Test**	Trial 1	1 run	Passed after modifications
9	**Boundary-Adequacy Test**	Trial 12	2 runs	Passed after modifications
10	**Extreme-Conditions Test**	Trial 2-Trial 6	5 runs	Passed after modifications
11	**Dimensional Consistency Test**	n/a	n/a	Passed after modifications
12	**Extreme-Conditions Test**	Trial 7-Trial 8	2 runs	Passed without any modifications
13	**Behavior- Abnormally Test**	Trial 9	1 run	Passed without any modifications

14	**Assumptions Sensitivity Test**		3 runs	Passed without any modifications
15	**Face Validity Test**	Trial 1	1 run	Passed after modifications
16	**Dimensional Consistency Test**	n/a	n/a	Passed without any modifications
17	**Extreme-Conditions Test**	Trial 9-Trial 10	2 runs	Passed without any modifications

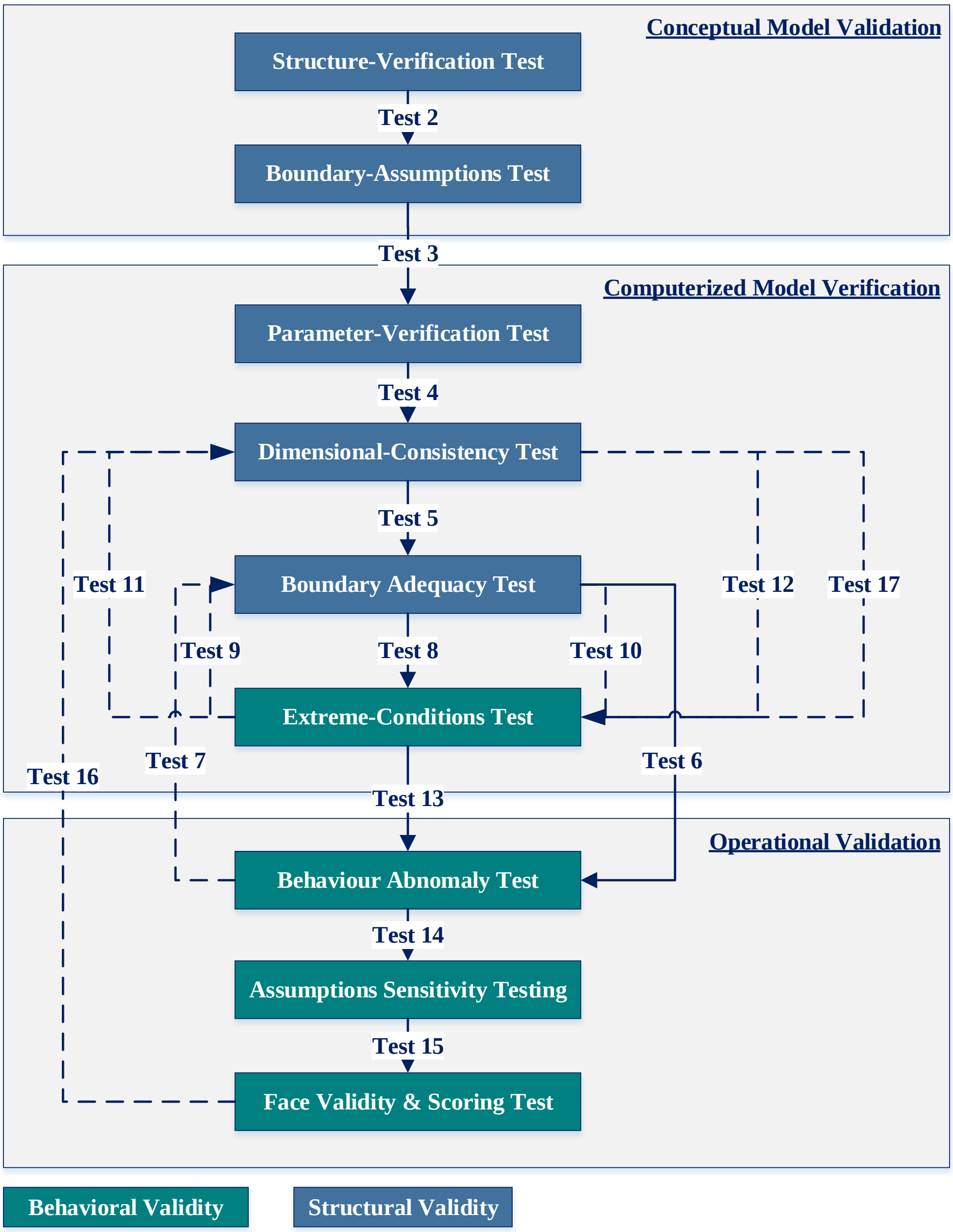


Figure 20: Process Diagram of the Model Validation Tests

7.3.1. Conceptual Model Validation

As suggested by various authors (i.e. [303], [442]), during the Conceptual Model validation, the focus in on a) having appropriate representation of the SM based on BSC Structure, and b) having appropriate causal relations between the KPIs given in the BSC Structure. It is known that; in case the SMS has misrepresented or causal relations in the map were faulty, simulations generated from the Computerized Model would be misleading. Thus, a number of Structural Validity tests were conducted in order to ensure "right behavior for the right reasons" [308]. As the stakeholders of the model (Company Experts), were involved in the development process of the Conceptual Model through a serial GMB sessions, it was anticipated that the model credibility is satisfactory [455].

7.3.1.1. Structure- Verification Test

Purpose: The aim of the Structure Verification Test is to check whether the model structure is consistent with relevant descriptive knowledge of the system being modeled ([463], [80]) and adequately corresponds to the relevant descriptive knowledge of the real-world system [442].

Methodology/ Process: Similar to the methodology proposed by [462], before developing the Computerized Model, firstly structural validity of the Conceptual Model was tested through serial GMB sessions conducted by the Company Experts. The process and findings of the development process of the Conceptual Model can be found from previous chapters of this research. For example, in the final session, SMS was validated by the Company Experts by declaring that all cause-and effect chains as well as feedback loops in the SMS could highly reflect causalities inherit in real-life.

Findings/ Discussion: The frameworks (i.e. PESTBEL-F, RC-F, KPI-F), which were used to construct Conceptual Model, were developed based on the available literature, benchmarking initiatives and industry reports. These reports and studies served as a "theoretical" structural validation [79]. Similar to the work of [463] "the information included in the structure and all cause-and-effect chains of the causal loop diagram are based on a comprehensive literature review and the analysis of empirical data". Therefore, it was accepted that the structure of the Conceptual Model was logical and closely represented the actual system in the Company. In addition, these sub-models and causal relationships included in the Conceptual Model were developed based on the knowledge and experience of the Company Experts about the real system, which in turn provided a sort of 'empirical' structural validation [448]. After first five GMB sessions, it was ensured that both the Conceptual Model and Computerized Model were structurally verified. Structure of the Computerized Model was also reviewed and tested with Company Experts in Session 6.

7.3.1.2. Boundary-Assumptions Test

Purpose: This test examines the boundary conditions and their adequacy to real system by verifying whether,

- the important concepts and structures for addressing the subject questions/issues are endogenous to the model,
- the model structure is appropriate for the model purpose,
- the behavior of the model will change significantly when boundary assumptions are relaxed,
- outputs of the model will change when the model boundary is extended ([67], [442], [308]).

Methodology/ Process: After structural validation was ascertained, some boundary conditions and assumptions were developed by the researcher in order to set the limits for the simulations. Boundary conditions and assumptions were validated again by Company Experts during Session 5. Prior to the Session 5, researcher listed the boundary conditions and associated parameters with also explaining why the selected parameters were chosen. A secondary list was also prepared by the modeler, which contains assumptions about both the Conceptual Model and Computerized Model. Boundary conditions and assumptions of the model are summarized in Chapter 6, validated in Session 5 as given in Table 41 as well as listed in Appendix 7.

Findings/ Discussions: The boundary conditions were reviewed and if necessary, modified by the Company Experts before developing the Computerized Model.

7.3.2. Computerized Model Verification

After the structural verification and boundary adequacy of the Conceptual Model were ascertained, the mathematical formulations were produced by the researcher. These formulations were transformed into a Computerized Model using Stella Architecture by the researcher. After the initial Computerized Model was developed Dimensional Consistency, Boundary Adequacy and Extreme Conditions Tests were carried out to ensure both the structural and behavioral validity of the model. To do so; company-specific input data were gathered from the annual reports of the Company by the researcher and used when conducting these tests.

To be highlighted that, after each validation test, if necessary, some pre-conducted tests were repeated. For example; after Extreme Conditions tests, it was observed that there existed some flaws in the boundary conditions of the model, so that some additional boundary conditions were added and reflected to the model structure after the approval of the Company Experts. Therefore, as the model passed more tests, the confidence level was improved [462].

After iterative testing and modification trials, the final Computerized Model was formed. As a further approach, the last structural validation test, Behavior Abnormally Test, was applied by the researcher, in order to test whether the model was still reliable when the real life parameters were assigned to the model.

7.3.2.1. Dimensional-Consistency Test

Purpose: This test examines the appropriateness of dimensions utilized in equations by questioning whether,

- each equation is dimensionally consistent with the use of parameters [67],
- dimensions of variables in the model correspond to the unit in which they can meaningfully express the real variables, which exist in the company ([454], [442]),
- the units of measure of variables on both sides of the equation are equal [454].

Methodology/ Process: In current literature, this test has generally conducted by using built-in functions of software tools for SD model development (i.e. [454], [463], [442]). For example, [463] utilized a function of the Vensim, a SD modelling tool, to check dimensional consistency. In this study, the model was also verified in dimensional consistency by using of the Stella Architecture, which has a 'units check' function to verify dimensions automatically after measurement units of model parameters were defined. This test ensured that measurement units of all parameters in the Computerized Model were consistent in dimension.

Findings/ Discussion: In the first modelling exercise, it was observed that Stella Architecture gave more than 100 unit warnings. Then some modeifications were made in Conceptual and Computerized Model until the consistency was ensured. These modifications are explained in Appendix 9. As the dimensional consistency was automatically tested by Stella Architecture, there was no need to conduct a separate test or GMB session. Some screenshots from the Stella Architecture are depicted in Figure 21 to Figure 23, to illustrate how the dimensional consistency was checked automatically.

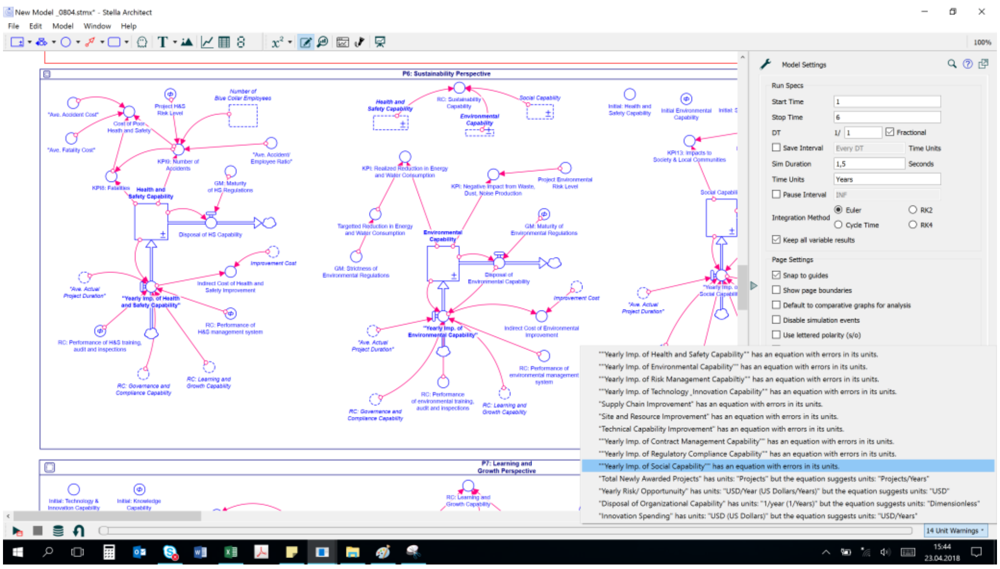


Figure 21: Dimensional- Consistency Test- Screenshot 1 from Stella Architecture

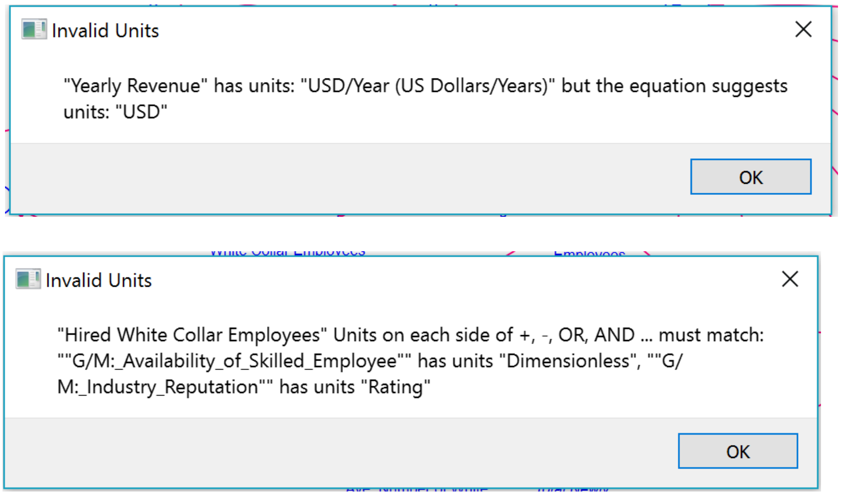


Figure 22: Dimensional- Consistency Test- Screenshot 2 from Stella Architecture

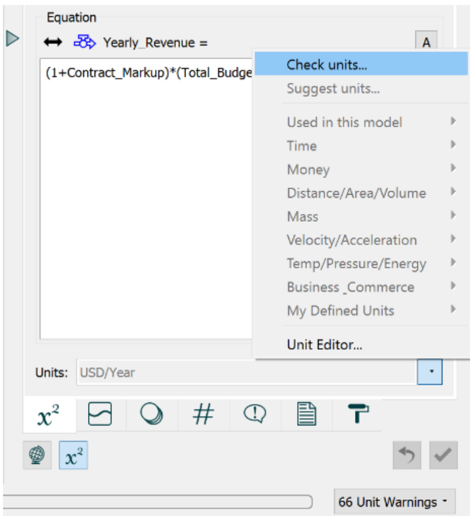


Figure 23: Dimensional- Consistency Test- Screenshot 3 from Stella Architecture

7.3.2.2. Boundary Adequacy Tests

Purpose: This test examines the behavior of the model by assigning extreme values to the model parameters in verifying whether the parameters having boundary conditions exceeds the thresholds defined in the model.

Methodology/ Process: Boundary conditions were assigned in Stella Architecture by “simulation events” function for associated parameters. The “simulation events” function enabled to stop the simulation when any parameter, for which boundary conditions were defined, exceeds or drops below the thresholds. The tool also gave an alert about in which parameter the boundary conditions were failed. Screenshots from the Stella Architecture showing “simulation events function” are given in Figure 24 and Figure 25.

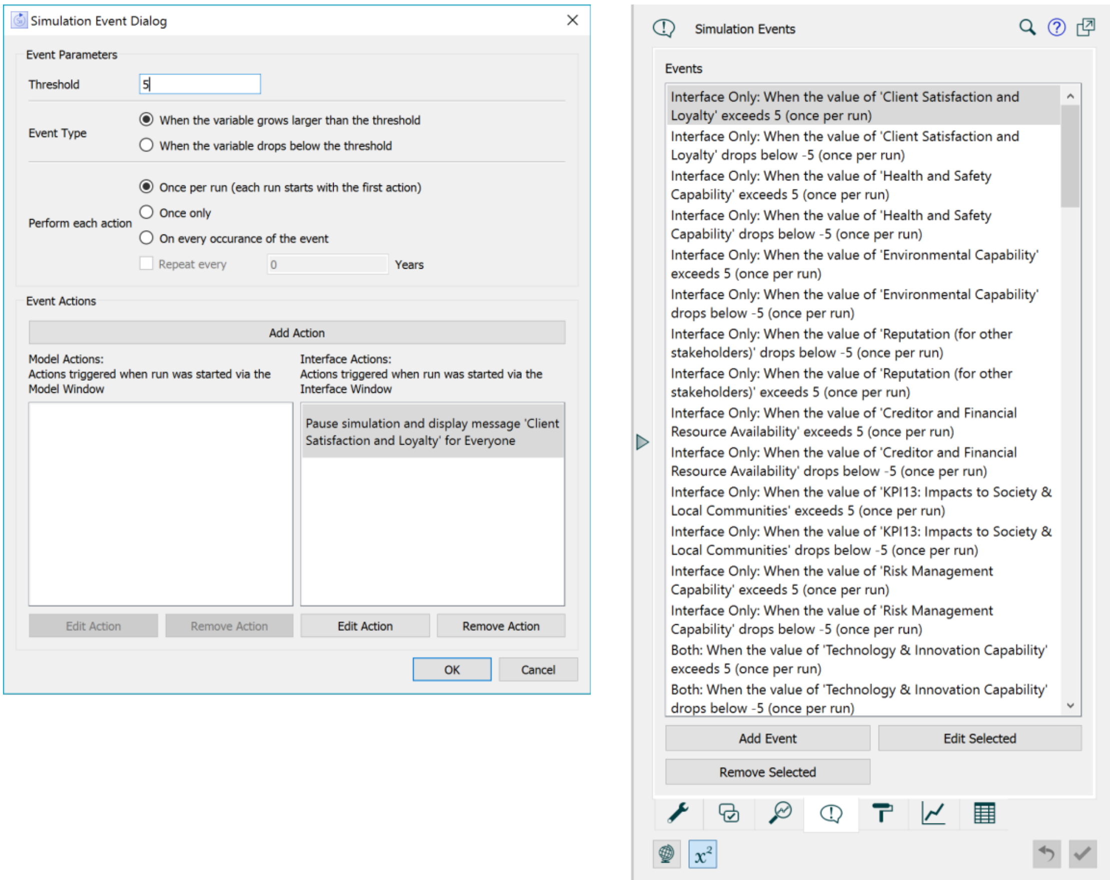


Figure 24: Boundary Adequacy Test- Screenshots from Stella Architecture

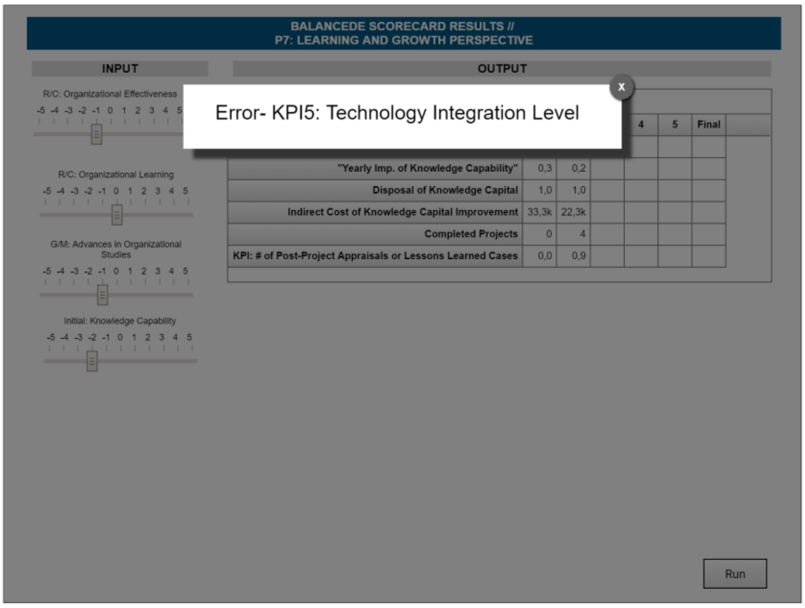


Figure 25: An Example from Boundary Error

The following methodology was conducted in the context of Boundary Adequacy Test,

1. All input values, except the ones those tested for boundary adequacy, were fixed to two.
2. Then tested input parameters were assigned as 5 or -5 depending on the extreme boundary condition tested (5 for extreme positive, -5 for extreme negative cases).
3. All strategic objective groups were tested for extreme positive and negative cases respectively.
4. After each run, any errors on boundary conditions were documented. Boundary errors are the errors, those occur when outputs will be higher or lower than the thresholds defined in the tool. As mentioned previously, the Stella Architecture tool provided development of the boundary condition to the tool, and gave automatic warnings when any output in any simulation time is inconsistent with these conditions.
5. After boundary conditions of parameters representing the strategic objectives were tested, trials were finished and errors were analyzed.
6. For each trial, the most vulnerable parameters (the most observed errors) were examined in detail and their Conceptual or Computerized Model was changed, accordingly.
7. After boundary conditions were ensured in each strategic objective group separately, the conditions were tested for the each perspective as a whole.
8. When testing boundary conditions of parameters included in a perspective as a whole, all input parameters given in related perspective were selected as 5 or -5 depending on the type of extreme condition.
9. Boundary conditions were also re-conducted with higher simulation times. Although the simulation time was decided as 5 years with Company Experts, in order to test the model in extreme conditions in more simulation years, the Computerized Model was also simulated for 10 and 15 years, respectively.
10. To be noted that, during test 5 (Preliminary Behavior Abnormally Test) or test 7 (Extreme- Conditions Test), some modifications in both Conceptual and Computerized Model were made. Thus, Boundary Adequacy Test was re-conducted in order to ensure boundary conditions were still valid.

Findings/ Discussion: 211 simulation runs were conducted in 12 iterative trials. 349 outputs were generated from these 12 trials, from which 189 boundary errors were obtained. 189 errors were examined in detail, some modification in Conceptual or Computational Model was made in order to ensure boundary adequacy. In final, none of the parameters was failed in extreme conditions under boundary adequacy considerations. The log of the each trial/ run conducted were recorded, along with the parameters tested, input assigned (extreme positive or negative conditions), and output parameter that were failed. The modifications made to ensure boundary adequacy are also given in Appendix 9. As can be seen from Appendix 9, 15 major modifications were made both in Conceptual and Computational Model.

Table 49 to Table 51 represent the summary of the Boundary Adequacy Test by analyzing the distribution of boundary errors based on conditions tested (extreme negative or positive), based on associated perspectives of parameters as well as based on output parameters that failed in boundary conditions.

Table 49: Distribution of Number of Boundary Adequacy Errors/ Condition Tested

Extreme Condition Tested	Trial							Total
	1	2	3	4	5	7	11	
Extreme negative (-5)	68	48	5	8	5	3	2	139
Extreme positive (5)	37	13						50
Total	**105**	**61**	**5**	**8**	**5**	**3**	**2**	**189**

Table 50: Distribution of Number of Boundary Adequacy Errors/ Perspectives

Perspective	Trial							Total
	1	2	3	4	5	7	11	
Governance and Compliance	24	20	3	3	2	3		55
Learning and Growth	29	9	1	1	1		2	43
Market and Business Growth	5	3						8
Project Management	9	7						16
Stakeholder	5	6	1	4	2			18
Sustainability	33	16						49
Total	**105**	**61**	**5**	**8**	**5**	**3**	**2**	**189**

Table 51: Distribution of Number of Boundary Adequacy Errors/ Output Parameters

Output Parameters	Trial							Total
	1	2	3	4	5	7	11	
Annual Salary of Other White Collar Employee			1					1
Claim Mitigation Performance	1	1	1	1	1			5
Client Retention Rate	7	8		1				16
Client Satisfaction and Loyalty	7	8		1				16
Contract Management Capability	1	1	1	1	1			5
Creditor- Financial Resource Availability	16	10		1				27
Governance and Compliance Capability						1		1
Gross Profit Margin							1	1
Health and Safety Capability	2							2
Knowledge and Intellectual Capability	8	3						11
Net Profit Margin							1	1
Ongoing projects- international	10							10
Ongoing projects- National	10							10
Regulatory Compliance Capability	2	1	1	1		1		6

Regulatory Issues Mitigation Performance						1		1
Reputation for other stakeholders	12	10		1				23
Residual Cost Overrun Risk		1			1			2
Residual Delay Risk		1			1			2
Technology and Innovation Capability	11	17	1	1	1			31
Total number of employees	18							18
Total	**105**	**61**	**5**	**8**	**5**	**3**	**2**	**189**

Some discussions regarding boundary adequacy error are as follows,

- Most of the errors were observed in extreme negative conditions such that 139 of the 189 errors were occurred when parameters were simulated in input values having -5.
- Most of the errors were observed after the first trial (105 out of 189 errors). Then after the first trial, considerable amount of modifications were made in Conceptual and Computerized Model. Therefore, in the second trial the number of errors was declined to 61.
- Most of the errors (55 out of 189 errors) were observed when the parameters of the “Governance and Compliance Perspective” were tested. The following perspectives, which gave highest number of errors, were “Sustainability Perspective” (48 out of 189 errors), and “Learning and Growth Perspective” (43 out of 189 errors). However, after the model modifications were made in parameters of “Governance and Compliance Perspective” during the first and second trial, number of errors obtained in “Learning and Growth Perspective” and “Sustainability Perspective” were declined with the third trial.
- Although the boundary errors were least observed in parameters on “Market and Business Growth Perspective”, after the Behavior Abnormally Test, it was observed that there were some behavioral inconsistencies despite the fact that the conceptual parameters of the “Market and Business Growth Perspective” were structured properly. Thus, some material modifications were made in Computerized Model of this perspective. The log of the model modifications is given in Appendix 9.
- Most of the errors (31 out of 189 errors) were observed in the parameter named “Technology and Innovation Capability”. While trials were examined separately, after the first trial the most sensitive parameters, which were highly prone to boundary conditions, were observed as; a) ongoing international and national projects, b) total number of employees, c) creditor- financial resource availability.
- After the Boundary Adequacy Test, it was understood that boundary errors might occur due to three reasons. First, the mathematical equations of related parameters might be wrong, second excessive number of or unrelated relations might be assigned to the parameters, or underlying conceptual or computerized assumptions of the parameters might be wrong or misleading.
- As given in the Model Modifications Log in Appendix 9, some modifications were made to correct mathematical equations of the parameters, some were about Conceptual Model relations among parameters, or totally about underlying assumptions premised when developing Conceptual or Computerized Model.

7.3.2.3. Extreme-Conditions Test

Purpose: This test examines the behaviors of the model by assigning extreme values to the model variables in verifying whether,

- each equation is reasonable and model exhibits a logical output even when its inputs take on extreme values,
- the model responds plausibly subject to extreme policies, shocks and parameters,
- behavior of the model in extreme conditions matches the behavior of the real system in same situations ([67], [463], [454], [442], [303]).

Methodology/ Process: After the boundary adequacy was ensured, Extreme Condition Test was conducted iteratively. During this test, a similar methodology proposed by various authors such as [454], [461], [464], [442] was conducted. The followed methodology is as follows,

1. Extreme values (extreme negative as -5, extreme positive as 5) were assigned to selected parameters as input values.
2. Different from boundary adequacy test, model-generated behavior, which was real outputs, were compared to the real system behavior.
3. The outputs, which were decided as variant from real system behavior, were identified and labelled.
4. The Conceptual and Computerized Models of the labelled parameters were evaluated and modified as explained in Appendix 9.
5. After each modification, the Extreme Conditions Test was re-conducted until the outputs reasonably reflected the behavior of the real system.

The evaluation of the model outputs under extreme conditions was based on the mental models of the researcher. An example about how the decisions were made by the researcher about the comparison of the model behavior and real system behavior was given as follows,

- If the national and international demand for the construction projects is equal to zero during the whole simulation, then the number of newly awarded projects should be zero.
- Respectively any additional project budget and revenue from the newly awarded projects will not be expected.
- After the current ongoing projects will be finished, then revenue of the company should decline to zero, as there is no newly awarded projects.
- The decline in the current ongoing projects will also cause employee to exist.
- The indirect costs associated with the G&A expenses should also be zero as there is no revenue to invest in the improvement of organizational capabilities managed by support services/ head offices.

Findings/ Discussion: Eight simulation runs were conducted in eight iterative trials. Considering that it is not practical to demonstrate the entire testing process due to limited space of this research, the findings of the Extreme Conditions Test were not given. However, as given in Table 52, it was observed that the Computerized Model was failed in 18 parameters under extreme conditions. These parameters were Mxamined in detail, some modification in Conceptual or Computational Model were made in order to ensure behavioral validity in extreme conditions. After the model modifications, it was decided that the Computerized Model gave reasonable outputs while compared with the real system. The log of the each trial/ run conducted were recorded along with the parameters tested, input assigned (extreme positive or negative conditions), and output parameter that were failed.

The modifications made to ensure extreme conditions are also given in Appendix 9. As can be seen from Appendix 9, 10 major modifications were made both in Conceptual and Computational model.

Table 52: Parameters Failed in Extreme Conditions Test

Perspective	Model Parameter (*)
Financial Perspective	1. Yearly Revenue Growth 2. Yearly Other Income 3. Yearly Operational Expenses 4. Yearly Gross Profit/ Loss 5. Yearly Net Profit/Loss 6. Tax Paid
Market and Business Growth Perspective	7. Newly Awarded International Projects 8. Newly Awarded National Projects 9. Budget Gain from Newly Awarded Projects
Project Management Perspective	10. Total Earned Duration for Work Performed 11. Ave. Actual Project Duration 12. Ave. Schedule Variation 13. Time Management Performance
Governance and Compliance Perspective	14. Claim Mitigation Performance 15. Regulatory Issues Mitigation Performance
Learning and Growth Perspective	16. % High Talented Employees 17. Number of High Skilled Employees 18. Total Annual Salary of Other White Collar Employees

(*) The model parameters are re-named after the model modifications.

7.3.2.4. Parameter-Verification Test

Purpose: This test examines whether the parameter values are consistent with relevant descriptive and numerical knowledge of the system, and whether all parameters have real system counterparts or not ([67], [442]).

Methodology/ Process: A methodology similar to the authors (i.e. [442], [463], [467]) was conducted to ensure parameter verification. The values assigned to the parameters were gathered by individual knowledge of Company Experts, which were captured during the Session 5. In addition, real data were also provided by the Company Experts during Session 7 to produce a Baseline Test for the simulation exercises.

Findings/ Discussion: As the Company Experts set the values to each parameter, it was ensured that the Computerized Model wasvalid under Parameter Verification Test. The list of real data for model parameters is given Chapter 8 in Baseline Testing.

7.3.3. Operational Validation

Once both the structural and behavior validity tests were performed to ensure Conceptual and Computerized Model validation, Behavior Abnormally Test, Assumptions Sensitivity Test and Face Validity Test were performed to ensure model-generated behavior mimics the observed behavior of the real system ([449], [468], [80], [448], [442]).

7.3.3.1. Behavior- Abnormally Test

Purpose: This test examines whether the Computerized Model-generated behavior reflects the observed behavior of the real system ([449], [468], [80], [448], [442]).

Methodology/ Process: During the Behavior-Abnormally Test, methodology conducted is as follows,

1. Input parameters, which were defined by the Company Experts in Session 5, were assigned to the Computerized Model in Stella Architecture.
2. The outputs generated from the Stella Architecture were examined in detail, and the model-generated behavior was compared to the real system behavior as understood.
3. The outputs, which were decided as variant from real system behavior, were identified and labelled.
4. The Conceptual and Computerized Model of the labelled parameters were evaluated and modified as explained in Appendix 9.
5. After each modification, the Behavior-Abnormally Test was re-conducted until the outputs reasonably reflected the behavior of the real system.
6. After preliminary Behavior-Abnormally Tests (Trial 1-8), Boundary Adequacy Test, Extreme-Conditions Test and Dimensional Consistency Test were re-conducted in order to ensure the model was still valid under these tests.
7. After final Behavior-Abnormally Test, Face Validity Test was carried out with the Company Experts in Session 6.

Findings/ Discussion: Eight simulation runs were conducted in eight iterative trials. Considering that, it was not practical to demonstrate the entire testing process due to limited space of this research, the findings of each trial/ run conducted in the behavior-abnormally test cannot be given. As given in Table 53, it was observed that the model was failed in 18 parameters under extreme conditions. These parameters were examined in detail, some modification were made in Conceptual or Computerized Model modifications in order to ensure behavioral validity in extreme conditions. After the model modifications, it was decided that the model gave reasonable outputs while compared with the real system. The log of the each trial/ run conducted was recorded along with the parameters tested, input assigned and output parameter that are failed.

As can be seen from Appendix 9, 10 major modifications were made both in conceptual and computational model.

Table 53: Parameters Failed in Behavior Abnormally Test

Perspective	Model Parameter (*)
Financial Perspective	1. Contract Markup 2. Risk-Related Contingency 3. Residual Cost Overrun Risk 4. Targeted Budget of Potential National Projects 5. Targeted Budget of Potential International Projects 6. Yearly Gross Profit/Loss 7. Gross Profit/Loss 8. Yearly Net Profit/Loss 9. Net Profit/Loss
Market and Business Growth Perspective	10. Newly Awarded International Projects 11. Newly Awarded National Projects
Project Management Perspective	12. Yearly Realized Budget 13. Total Estimated Cost to Complete 14. Total Cost Variation 15. Ave. Actual Project Duration 16. Ave. Planned Project Duration 17. "Ave. Schedule Variation
Learning and Growth Perspective	18. Required Blue Collar Employees 19. Hired Blue Collar Employees 20. Blue Collar Employee Exists 21. Total Number of Employees 22. Innovation Spending 23. Revenue from Innovation

(*) The model parameters are re-named after the model modifications.

7.3.3.2. Assumptions Sensitivity Test

Purpose: This test explores whether the Computerized Model still generates behaviorally valid outputs when its model assumptions, which have a numerical condition or assumption, are changed.

Methodology/ Process: The methodology of Assumptions Sensitivity Testing is as follows,

1. Model assumptions given in Appendix 7 and model equations given in Appendix 8 were reviewed by the researcher to capture the assumptions including a numerical condition or assumption.
2. As given in Table 54, nine equations were defined, for which numerical conditions or assumptions were assigned by the researcher, previously.
3. Although these equations and assumptions were also validated by the Company Experts in Session 5, still it was aimed to conduct some serial sensitivity tests to understand the behavioral implications of probable changes in their values.

4. For each nine equation, to test their sensitivity to the numerical values assigned, four optional values were also defined. As given in Table 54, the existing/ baseline values defined in the model equations are represented as “Exis.”, and optional values tested as “Opt1”, “Opt2, “Opt3” and “Opt4”, respectively.
5. Four sensitivity tests were conducted separately for each nine equation with using the pre-defined optional values.
6. The outputs generated from the Stella Architecture for each sensitivity test were examined in detail, and the model-generated behaviors for each options were compared with the baseline values.
7. For example, in model assumption having ID 17, “Number of Fatalities” were assumed that, if “Health and Safety Capability” of the Company is low, then 5% of the probable accidents may turn into fatailities. The assocated formula is as follows;

    a. Number of Fatalities = IF(Health and Safety Capability<0) THEN Number of Accidents*0,05 ELSE 0

8. Thus in Assumptions Sensitivity Test, it was tested whether the ouputs generated from the Computerized Model would give misleading or unrealistic results (from either the real life or behavior obtained from the original assumption) if the 5% numerical assumption would be 1% (Opt1), 10% (Opt2), 15% (Opt3) and 20% (Opt 4).
9. To do so, variations among outputs generated for baseline test representing original assumption, and for optional values were calculated.
10. Variations were further discussed with Company Experts in Face Validity Test in Session 6.

Findings: 36 sensitivity tests were conducted to analyze four options of nine equations. The results derived from the Stella Arhitecture revealed that, except test 1, test 3 and test 6 (as given in Table 54), the variance among baseline values and optional values gave zero, showing that the key outputs were not sensitivite to the numerical conditions/ assumptions assigned to the equations. However, in test 1, test 3 and test 6, variances were occurred among baseline and optional values. For example, the results showed that the parameter “net profit” was sensitive to the degree of “innovation spending” as understood in test 6. In addition, test 3 was showed that “Risk-Related Contingency” affect the value of “net profit” and “operating profit”. The highest sensitivite parameter was obtained as “targeted number of international/national projects”, as any changes in the value of this parameter highly affect outputs, such that except one, it highly changed values of all outputs. The comparable results of test 1, test 3 and test 6 are given in Table 55, Table 56 and Table 57, respectively.

As a further efffort, the results of Assumptions Sensitivity Testing were discussed with Company Experts in Session 6 to ensure whether sensitivites of parameters and variances obtained were acceptable to them. They argued that; although variances in Test 1 was critical, as any changes in the equation of “targeted number of international/national projects” have potential to manipulate the results of the remaining model parameters, they still accepted the success of the model under these model assumptions. However, they added that; these numerical conditions could be defined as "input parameter" in the Computerized Model rather than embedding them in the model equations.

7.3.3.3. Face Validity Test

Purpose: Face Validity Test was conducted to understand whether the model behavior statistically like data from real system from the point of view of Company Experts. It is partly similar to the Statistical Test proposed by [79] as well as Statistical Test, Behavior Reproduction Test suggested by [80]. Face Validity Test is more oriented towards to the investigation of operational validity by ensuring behavioral validity of the Computerized Model. In addition to the behavioral validity, this test also aims to understand the structural validity of the Computerized Model by asking questions about its level of simplicity, complexity, comprehensiveness or suitability.

Methodology/ Process: Face Validity Test was conducted with the 5 C-Level executives of the Company in the form of Session 6. The methodology of Session 6 is given in Table 58. Face Validity Test was carried out in two agenda; first the output generated from the Computerized Model as a preliminary Baseline Testing were reviewed and discussed by the Company Experts. Second feedbacks of the Company Experts were collected via a structured questionnaire.

As part of the first agenda, the input values, which represent the baseline scenario/strategy of the Company, were assigned in the Computerized Model. To be noted that, these input values were gathered from the Company Experts in Session 5. The outputs generated from the Computerized Model were reviewed and discussed by Company Experts in Session 6 to understand behavioral and operational validity of the model under current strategies of the Company and existing external environment. This test was regarded as a preliminary test for the Baseline Testing explained in Chapter 8. The feedbacks of the Company Experts about the outputs were obtained as well modifications required to enhance model validity were captured by the researcher.

In the second part of the Session 6, the questionnaire given in Table 59, were distributed to the Company Experts. This section was conducted as a discussion sessions among Company Experts to elaborate their way of thinking about model validity and their level of confidence for the model and its outputs.

Findings/ Discussion: The discussions of the Company Experts about the findings of the preliminary Baseline Testing reflected that some modifications were needed for both the Conceptual and Computerized Model. As given in Appendix 9, these modifications were reflected to the Computerized Model as a post-session study by the researcher. The discussions of Company Experts during the Face Validity Test and modifications made after the test can be found in Appendix 9.

Table 54: Summary of Assumptions Sensitivity Testing

Assumptions Sensitivity Testing - Summary													
Test ID	**ID**	**Assumption Name**	**Formula Changed**	**Equation**	**Exis.**	**Opt 1**	**Opt 2**	**Opt 3**	**Opt 4**	**Var 1**	**Var 2**	**Var 3**	**Var 4**
1	**24**	MA7- Market Attractiveness	Targeted Number of National Projects Targeted Number of International Projects	Targeted Number of National Projects = IF Attractiveness of National Construction Market>=0 AND Attractiveness of International Construction Market>=0 THEN (IF(Attractiveness of National Construction Market-Attractiveness of International Construction Market>=0) THEN (IF TIME>1 THEN (Manageable Max Number of National Projects -National Projects Completion Rate)* 0,7 ELSE National Projects Completion Rate***2)** ELSE National Projects Completion Rate) ELSE National Projects Completion Rate***0,8**	2	1	3	4	5	Yes/ High	Yes/ High	Yes/ High	Yes/ High
2	**28**	MA7- Market Attractiveness			80%	0%	25%	50%	100%	No	No	No	No
3	**47**	MA15- Residual Delay/ Cost Overrun Risk	Risk-Related Contingency	"Risk-Related Contingency" = IF (Residual Cost Overrun Risk=1) THEN 0 ELSE (Residual Cost Overrun Risk***2)**	10%	0%	5%	15%	25%	Yes/ Medium	Yes/ Medium	Yes/ Medium	Yes/ Medium
4	**55**	MA17- Number of Fatalities & Accidents	Fatalities	Number of Fatalities = IF(Health and Safety Capability<0) THEN Number of Accidents***0,05** ELSE 0	5%	1%	10%	15%	20%	No	No	No	No

5	**58**	MA19-Reduction in Energy and Water Consumption	Targeted Reduction in Energy and Water Consumption	Targeted Reduction in Energy and Water Consumption = **30***(50+(GM: Strictness of Environmental Regulations*10))/100	30%	10%	20%	40%	50%	No	No	No	No
6	**65**	MA21-Innovation Spending and Revenue from Innovation	Innovation Spending	Innovation Spending = IF("G/M: Benefits Provided for Innovation">0) THEN Yearly Realized Budget***0,01** ELSE Yearly Realized Budget*0,03	1%	2%	3%	4%	5%	Yes/ Low	Yes/ Low	Yes/ Low	Yes/ Low
7	**66**	MA21-Innovaton Spending and Revenue from Innovation	Innovation Spending	Innovation Spending = IF("G/M: Benefits Provided for Innovation">0) THEN Yearly Realized Budget*0,01 ELSE Yearly Realized Budget***0,03**	3%	1%	5%	10%	20%	No	No	No	No
8	**77**	MA22-Employee Hires and Exists	Hired High Skilled Employees	Hired High Skilled Employees = **0,1***Hired White Collar Employees*((50+("Reputation (for other stakeholders)"*10))/100)	10%	5%	20%	30%	40%	No	No	No	No
9	**80**	MA23-Implemented Innovation Initiatives	Targeted Innovation Initiatives	Targeted Innovation Initiatives = IF("G/M: Advances in Technology">=3) THEN **10** ELSE IF("G/M: Advances in Technology">0 AND "G/M: Advances in Technology"<3) **THEN 8 ELSE 5**	10-8-5	5-3-2	15-12-8	20-15-10	30-25-20	No	No	No	No
				Options are about numbers represented in bold.									

Table 55: Analysis of AST Test 1 Findings

At Year 5 - Outputs									
	Existing	**Opt 1**	**Opt 2**	**Opt 3**	**Opt 4**	**Var 1**	**Var 2**	**Var 3**	**Var 4**
Yearly Total Budget of Newly Awarded Projects	1.474,10	1.474,10	1.480,50	1.509,00	1.493,20	0,00	6,40	34,90	19,10
Yearly Gross Profit	1.172,30	1.172,30	1.188,10	1.170,10	1.220,00	0,00	15,80	-2,20	47,70
Yearly Net Profit	1.058,70	1.058,70	1.066,90	1.044,00	1.082,90	0,00	8,20	-14,70	24,20
Total Ongoing Projects	18,00	18,00	18,00	18,00	18,00	0,00	0,00	0,00	0,00
Total Completed Projects	48,00	48,00	50,00	50,00	54,00	0,00	2,00	2,00	6,00
Total Number of Newly Awarded Projects	8,00	8,00	8,00	8,00	8,00	0,00	0,00	0,00	0,00
Total Cost Variation	294,20	294,20	311,10	312,60	344,60	0,00	16,90	18,40	50,40
Total Realized Budget	4.556,70	4.556,70	4.818,10	4.841,30	5.336,40	0,00	261,40	284,60	779,70
Total Number of Employees	10.655,00	10.655,00	10.676,00	11.110,00	11.125,00	0,00	21,00	455,00	470,00

Table 56: Analysis of AST Test 3 Findings

At Year 5 – Outputs					
	Existing	**Opt 1**	**Opt 2**	**Opt 3**	**Opt 4**
Yearly Gross Profit	1.172,30	613,00	752,80	1.451,90	2.011,10
Yearly Net Profit	1.058,70	499,40	639,20	1.338,30	1.897,50

At Year 5 - Variance				
	Var 1	**Var 2**	**Var 3**	**Var 4**
Yearly Gross Profit	-559,30	-419,50	279,60	838,80
Yearly Net Profit	-559,30	-419,50	279,60	838,80

Table 57: Analysis of AST Test 6 Findings

At Year 5 - Outputs					
	Existing	**Opt 1**	**Opt 2**	**Opt 3**	**Opt 4**
Yearly Net Profit	1.058,70	1.196,10	1.333,60	1.471,10	1.608,60

At Year 5 - Variance				
	Var 1	**Var 2**	**Var 3**	**Var 4**
Yearly Net Profit	137,40	274,90	412,40	549,90

Table 58: Face Validity Workshop

Session 6: Face Validity Workshop	
General Information	
Session Topic	Face Validity Workshop
Session Type	Group Modeling Workshop
Session Targets	• Validation of model outputs for Baseline Scenario to ensure behavioral validity • Obtain feedbacks of the company experts on structural and behavioral validity of the model
Session Duration	3 hours without any break
Participant Composition	
Size and composition	Top Management: 5 C-level managers
Management Support	Direct support: Workshop attendance and open conversation
Pre-Meeting Interviews	Pre-meeting interviews were not scheduled. However, the selected key outputs of the model for the baseline scenario were distributed to the participants one week before the workshop day.
Session Procedure	
Pre-Session Study	• Development of the Computerized Model in isee- Stella Architecture. • Simulation of the model with initial values obtained in Session 5. • Analysis of the results by the researcher • Selection of key outputs to distribute to the experts prior to the workshop
Session Input	Key Outputs for the Baseline Scenario
Session Agenda & Methodology	• Reviewing, examining and discussing key outputs of the Baseline Scenario • Obtaining feedbacks about the key outputs, capturing modifications those needed to enhance model validity from verbal statements of the experts • Distributing the Face Validity Questionnaire and obtaining answers of the Company Experts
Post-Session Study	Re-developing and reflecting necessary modifications to the Computerized Model
Plenary Sessions	Verbal statements were recorded to maintain opinions of Company Experts. These statements were utilized when making modifications in the model, re-developing model formulations as a post-session study.
Session Output	Final Computerized Model
Methodology, Tools and Facilitation Aspects	
Tools and Techniques	Group Brainstorming, Stella Architecture (SD tool)
Facilitators and their roles	Researcher was the facilitator. She opened dialogues, directed the session and interactively reflected the opinions of participants. Researcher did not add or reject any opinion proposed by participants.
Risks & Limitations	**Risk 24:** Difficulties in adapting "systems thinking", difficulties in understanding model formulations and "Stella Architecture", despite the training session

	Risk 26: Difficulties in interpreting the model outputs, not trusting the simulation results **Risk 27:** Confusion in comparing simulation results and real-life behavior as the model gives predictive results about future
Anonymity & Permissions	Participants' names, ideas and choices could be seen and shared by others. Participants could not reject or remove ideas of other participants. Although the company allowed to publish assessment and formulation results, they did not permitted to directly give real/ original initial values as they reflect the real financial, human resources and other data. Thus, some manipulations were made in original values; however, the underlying theory and simulation results were remained same.

In summary, nine tests were undertaken in the context of model validation;

1. Structure Verification Test,
2. Boundary Assumptions Test,
3. Dimensional Consistency Test,
4. Boundary Adequacy Test,
5. Extreme Conditions Test,
6. Parameter Verification Test,
7. Behaviour Abnormally Test,
8. Assumptions Sensitivity Test,
9. Face Validity Test.

Based on the findings of the tests, some set of modifications were made both in the Conceptual Model and in the Computerized Model. As a final effort, a Face Validity Test was conducted with the Company Experts to capture their attitudes and decisions on usability and reliability of the Computerized Model.

The summary of the validation tests, their goal and contexts, and their findings were summarized in Table 59. It is worth to pinpoint that, the study/table uses the questions similar to the questions as suggested by ([79] and [80]). These questions were also used during Face Validity Test in Session 6.

Table 59: Summary of the Validation Process

Goal	Context	Test	Basis	Test Question(s)	Testing Methodology
Conceptual Model Validation	Structural Validity	(1) Structure-Verification Test	[79]	Is the model structure not in contradiction to the knowledge about the structure of the real system, and have the most relevant structures of the real system been modelled? Does the model structure looks like the real system? Is the logic in the conceptual model correct?	GMB Sessions were conducted with Company Experts for validation purposes.
			[80]	Is the model structure consistent with the present state-of the- art?	
Conceptual Model Validation	Structural Validity	(2)Boundary-Assumptions Test	[79]	Whether the important concepts and structures for addressing the policy issue are endogenous to the model?	Boundary conditions, which were developed by the researcher was approved by the Company Experts in a GMB Session.
				“Is the model aggregation appropriate and includes all relevant structure containing the variables and feedback effects necessary to address the problem and suit the purposes of the study?”	
			[80]	Does the model contain the most important issues addressing a given problem?	
Computerized Model Verification	Structural Validity	(3) Dimensional-Consistency Test	[79]	Do the dimensions of the variables in every equation balance on each side of the equation?	Unit Check function of the Stella Architecture was used by the researcher.
				Are each equation in the model dimensionally correspond to the real system?	
			[80]	Is every equation dimensionally consistent without the necessity to use parameters that are non-existent in the real world?	
Computerized Model Verification	Structural Validity	(4) Boundary-Adequacy Test	-	Whether the parameters, which have boundary conditions, exceed the thresholds defined in the model in extreme conditions?	Simulation Events function the Stella Architecture was used by the researcher.

Computerized Model Verification	Behavioral Validity	(5) Extreme-Conditions Test	[79]	"Does every equation in the model make sense or the model exhibit logical behavior even if selected parameters are subjected to extreme but possible values of variables?"	Iterative tests were conducted by assigning extreme values to the model. The test was facilitated by the researcher using Stella Architect.
			[80]	Does every equation make sense even if the inputs reach extreme values?	
Computerized Model Verification	Behavioral Validity	(6) Parameter-Verification Test	[79]	"Do the parameters correspond conceptually and numerically to real life?	Quantitative and qualitative data for the given parameters were captured from company annual reports or mental models of the company experts.
				Are the parameters recognizable in term of real systems, or are some parameters contrived to balance the equations?	
				Whether the parameters in the model are consistent with relevant descriptive and numerical knowledge of the system?	
			[80]	Are the parameters consistent with the present state-of-the art?	
Operational Validation	Behavioral Validity	(7) Behavior Abnormally Test	[80]	Do the anomalies occur when the model assumptions have been removed?	Iterative tests were conducted by assigning extreme values to the model. The test was facilitated by the researcher using Stella Architect.
Operational Validation	Behavioral Validity	(8) Assumptions Sensitivity Testing		Whether the Computerized Model still generates behaviorally valid outputs when its model assumptions, which have a numerical condition or assumption, are changed.	Iterative tests were conducted by assigning extreme values to the model. The test was facilitated by the researcher using Stella Architect.

Operational Validation	Behavioral Validity	(9) Face validity test	-	Does the model behavior is reasonable?	GMB Sessions were conducted with Company Experts for validation purposes.
			[79]	Does the model behavior statistically like data from real system?”	
			[80]	Does the model endogenously generate the symptoms of the problem, the behavior of modes, phases, frequencies and other characteristics of the real system behavior?	
			[79]	What is the model’s simplicity or complexity, level of aggregation or richness of detail appropriate?	
			-	Does the model include meaningful and appropriate parameters?	
			-	Does the boundary conditions are set appropriately? Does the conceptual model has a suitable boundary?	
			-	Has the conceptual model been correctly translated into a simulation model?	

CHAPTER 8

SIMULATION USING THE CASE COMPANY DATA: STRATEGIC OPTIONS AND SCENARIO TESTING

This chapter explains the simulation step of the SDP, in which two-simulation practice, Scenario Testing and Strategic Options Testing, were undertaken with the Company. Scenario Testing is about testing the model under diverse future scenarios in which global and market conditions change due to the changes in external environment. Different from Scenario Testing, Strategic Options Testing is about testing the model under different strategic options in which resources and capabilities change in line with the different strategies tested by the Company. Thus, this chapter explains the methods and findings of Scenario Testing and then Strategic Options Testing, by firstly introducing the Baseline Testing. In the last section of this Chapter, a brief discussion is given about experiences of Company Experts on making simulations in strategic decision-making.

8.1. BASELINE TESTING

Prior to the simulation of the model with Scenario Testing and Strategy Options Testing, firstly some sorts of baseline conditions were needed in order to compare test findings with initial conditions. With this purpose, firstly, a Baseline Testing was conducted at the beginning of Session 7 by the input values reflecting current conditions and data of the Company. Both the qualitative and quantitative input values required to simulate the model was collected from the Company Experts in Session 5. The inputs, having quantitative nature, defined for the baseline testing is given in Appendix 11. Remaining inputs having qualitative nature are given Appendix 12 and Appendix 13, along with the inputs defined in Scenario Testing and Strategy Options Testing. To be noted that, both the qualitative and quantitative inputs of the Baseline Testing were remained same in all scenarios tested in Scenario Testing and in all strategic options tested in Strategic Options Testing.

After baseline conditions were gathered in the form of qualitative and quantitative input data, they were imported to the Model as the baseline scenario. The findings were analyzed and discussed by the Company Experts and found as sufficient to reflect real conditions or measures of the Company. The findings of Baseline Testing are given in Appendix 11.

As mentioned in Chapter 6.3., some examples from the Computerized Model are given in Appendix 10 in order to provide a visual representation about how the input values were assigned and outputs were generated from the Model. Appendix 10 includes some set of screenshots taken from the Stella Architecture, which represents Data Entry, Results and Dashboard Interfaces of the Model. As the Stella Architecture provides an empty interface for visualization purposes, these interfaces were developed by the researcher, based on the model requirements. In this regard, IW of the Stella Arcitecture was used in three ways; 1) to build Data Entry Interface for assigning input values for the model parameters, 2) to build Results Interface for representing outputs generated after simulations in tablular form, 3) to build Dashboard Interface for visualizing and comparing key outputs in graphical form. In this regard, the data and results of Baseline Testing are given in Appendix 10 to illustrate the use of Data Entry, Interface and Dashboard Interfaces of the Computerized Model.

Nevertheless; as a further effort, the outputs generated from the model were also compared with the historical financial data of the Company. The comparison of the outputs also portrayed that the model gave nearly similar financial ratios for measures calculated by the model and real data reported in Company IFRS financial reports. The comparison of model generated results and historical data is given in Table 60.

Table 60: Comparison of Baseline Test Findings with Company Historical Data

Ratios (m)	Real Historical Data				Findings of Baseline Testing
	2017	2016	2015	Average	
Net Profit/ Shareholder Revenue	0,06	0,05	0,09	0,07	0,09
(Tax Expenses + G&A Expenses)/ Shareholder Revenue	0,07	0,07	0,07	0,07	0,09
(Tax Expenses + G&A Expenses)/ Company Expenses	0,08	0,08	0,08	0,08	0,10
Net Profit/Gross Profit	0,59	0,63	0,83	0,68	0,80
Gross Profit/ Shareholder Revenue	0,11	0,08	0,11	0,10	0,10
Company Expenses/ Shareholder Revenue	0,88	0,92	0,89	0,90	0,91

8.2. SCENARIO TESTING

Although the future cannot be foreseen and there are many possible futures, exploring the future can inform present actions and decisions as well as mapping scenarios can provide a “possibility space” ([56], [50]). According to [57] “scenario analysis is a tool for ordering one’s perception about alternative future environments in which one’s decisions might be played”. Thus, the aim of conducting Scenario Testing was not about predicting the future, forecasting the most likely future or being right about the future. Rather, it was about triggering Company Experts to think of future performance of the Company based on diverse external conditions [50]. Another crucial intends of conducting Scenario Testing was to describe the external environment in which the Company operates with credible stories of future events, trends or developments [61].

8.2.1. Methodology of Scenario Testing

Scenario Testing was conducted with the four C-level executives in Session 7. The underlying methodology of Session 7 is given in Table 61. The testing procedure consisted of three main steps; namely, 1) identification of the future scenarios, 2) identification of the input values, and 3) analysis on the outputs generated.

Step 1: Identification of the Future Scenarios: The underlying methodology of the Scenario Testing was to obtain and compare results of performance measures based on the changing global and market conditions under diverse scenarios. To do so; three scenarios were defined and analyzed by the Company Experts in the context of Step 7, “Development of Future Scenarios”. As explained in Chapter 5 in detail, a theoretical base was used by the researcher and a structured scenario analysis process was undertaken with the participation of the Company Experts. The tested scenarios were defined as follows;

- Scenario 1: Mature and all in pocket
- Scenario 7: Sensitive future thinker
- Scenario 16: Maintain and Survive

These scenarios are given in Table 23: Scenario Formulation Matrix, in which probable storylines of each scenario and their implications for strategy provisions were explained. To remind that, Scenario 1 was about the most desirable future by assuming that PESTBEL conditions were completely defined as “opportunities” for the Company. In this scenario, the storyline was assumed as Company may focus on both existing clients and look forward to new clients, markets or investments. Due to demanding nature of the market (as advancements are growing), Company may need to have specific focus on improving sustainability, technology and human growth, corporate governance. Scenario 7 had more pessimistic nature than the first scenario; however, it still provided some opportunities for the Company. While compared with other two scenario, Scenario 7 was more about today’s conditions of external environment, with including both threats and opportunities. In Scenario 7, it was assumed that; social, environment and technological conditions might be threats, while political, economic or business conditions might not be so much pressuring. For example, although act of terrorism was existed (social condition) especially in Middle East regions, still international contractors do business in this region, indeed with higher contract profit margins due to the risk taken. Finally, Scenario 16 reflected the worst-case scenario, in which it was assumed that everything goes wrong and all PESTBEL conditions might be a threat for the international construction companies.

In session 7, these three scenarios were tested with four C-level executives namely; Company CEO, CFO, COO and CIO. As explained Table 63, these C-level executives are head of corporate departments, who are responsible from different strategic fields of the Company. For example, Company CFO is responsible from cash management, finance, accounting, treasury and budgeting practices of the Company, while COO is responsible from successful management of projects. Thus, it was accepted that, they could successfully analyze the findings of the test with different point of views as well as ensure comprehensiveness about discussions made for implications of different future scenarios.

Step 2: Identification of Input Values: Input values for each scenario, were decided by the Company Experts in Session 7. As the scenarios were about changes in the conditions of external environment, those changes were reflected in the model by defining different input values for model parameters representing global and market (GM) factors. Thus, in Session 7, values of GM factors were assigned by the Company Experts to reflect the probable conditions of different scenarios. To be noted that; values assigned to the other input parameters of the Model (i.e. initial and RC parameters) were remained same with the values assigned in Baseline Testing. In this regard, Company Experts assigned input values for GM factor for each scenario separately, based on the storylines of each given scenario. These input values of each scenario along with the output values generated from the model are given in Appendix 12.

Step 3: Analysis and Comparison of the Outputs Generated: The model was simulated three times for the three different scenarios by changing the values of GM parameters. The simulation practice was also undertaken in Session 7. As given in Appendix 11, Baseline Scenario, which represents findings of Baseline Testing, was also maintained in Scenario Testing. They were used for as a basis for comparing results of Scenario Testing with the results of Baseline Testing. The results of each scenario were also compared with each other to understand their cross-effect. After the results were generated and compared via the Model, an in-depth discussion was made by Company Experts to understand implications of different scenarios. These discussions were also made with the four C-level executives participated in Session 8.

Table 61: Scenario Testing Session

Session 7: Scenario Testing Session	
General Information	
Session Topic	Scenario Testing
Session Type	Testing and Discussion
Session Targets	• Defining values for input parameters of three scenarios • Obtain feedbacks of the company experts on structural and behavioral validity of the model under three scenarios
Session Duration	3 hours without any break
Participant Composition	
Size and composition	Top Management: 4 C-level managers
Management Support	Direct support: Workshop attendance and open conversation
Pre-Meeting Interviews	Pre-meeting interviews were not scheduled.
Session Procedure	
Pre-Session Study	• Conducting initial simulations via semi-hypothetical initial values • Analysis of the results by the researcher

	• Selection of key outputs to distribute to the experts prior to the workshop
Session Input	Initial Values for Baseline Scenario Three scenarios with Scenario Formulation Matrix
Session Agenda & Methodology	1. Reviewing, examining and discussing key outputs of the Baseline Scenario 2. Obtaining feedbacks about the key outputs, analysis of the structural and behavioral validity of the model under three scenarios
Post-Session Study	No
Plenary Sessions	Verbal statements were recorded to maintain opinions of Company Experts. These statements were utilized when making discussions about findings of the Scenario Testing as well as about current strengths and limitations of the model and recommendations for further researchers.
Session Output	Simulation results for the Baseline Testing Three simulation results for three different scenarios
Methodology, Tools and Facilitation Aspects	
Tools and Techniques	Group Brainstorming, Stella Architecture (SD tool)
Facilitators and their roles	Researcher was the facilitator. She opened dialogues, directed the session and interactively reflected the opinions of participants. Researcher did not add or reject any opinion proposed by participants.
Risks & Limitations	**Risk 24:** Difficulties in adapting "systems thinking", difficulties in understanding model formulations and "Stella Architecture", despite the training session. **Risk 25:** Difficulties in assigning initial values, especially those that require subjective judgements. **Risk 26:** Difficulties in interpreting the model outputs, not trusting the simulation results. **Risk 27:** Confusion in comparing simulation results and real-life behavior as the model gives predictive results about future
Anonymity & Permissions	Participants' names, ideas and choices could be seen and shared by others. Participants could not reject or remove ideas of other participants. Although the company allowed to publish assessment and formulation results, they did not permitted to directly give real/ original initial values as they reflect the real financial, human resources and other data. Thus, some manipulations were made in original values, however the underlying theory and simulation results remained same.

8.2.2. Findings of Scenario Testing

Due to the space limitations, the detailed discussions were given for only measures those selected as “key outputs” by the researcher. The detailed findings are given in Appendix 12.

Contract Profit Margin: Contract Profit margin was highly varied among scenarios such that profit margin obtained in Baseline Testing (10,3%) was increased in Scenario 1 (13,5%) and in Scenario 7 (11,3%), while decreased in Scenario 16 (4,8%). Company

Experts argued that, such variance in profit margin among given scenarios can also be expected in real life. For example, Scenario 7 gave slightly higher margin than Baseline Scenario, which also showed that Scenario 7 was more about outlook of today's conditions. Scenario 1 was the most desirable scenario, which was expected to give the highest profit margin. Company Experts first argued that they might expect much higher profit margins in Scenario 1 (such as 20% or more) as both the global and market conditions were so desirable. However; then they argued that, these conditions would not be helpful for only the Company, competitors could also benefit from these desirable future conditions. Thus, competition among companies might be one of risk that companies need to cope with, in a future environment exemplified in Strategy 1. Thus, high competition levels might force companies to leverage its profit margin in order to make reasonable bid offers and award new projects. Company Experts added that, as given by the model results, they expected lowest profit margin in Strategy 16. However; they claimed that profit margin may be much lower than the generated output (4,8%). After detailed discussions made, they understood that, although the external environment was not desirable, the Company had still resource and competencies as in the today's conditions. Thus, it was understood that, the model gave implications about having appropriate and sufficient amount of these RC was enabled to Company to make offers for the new awards.

Targeted Budget of Potential Projects: Targeted budget of potential projects were highly varied among scenarios. The model outputs for targeted budget for potential national projects were; 99 m$/project, 135,7 m$/project, 108,8 m$/project and 20,6 m$/project for Baseline, Scenario 1, Scenario 7 and Scenario 16, respectively. For international projects, these outputs were 406,6 m$/project, 563,8 m$/project 450,8 m$/project, and 187,5 m$/project. Company experts discussed that, in real life the highest targeted budget was also expected in Scenario 1, in which external environment was desirable to do business. For example, in Scenario 1, stable political conditions, economic wellness and mature laws and regulations can courage governments to invest in energy or infrastructure of their companies. Company experts argued that these projects would have higher amount of projects while compared with simple and one-off housing projects requiring limited contract amount.

Shareholder Revenue: Yearly shareholder revenue was also highly varied among scenarios such that revenue gained in Baseline Testing (3.956 m$/ year) increased in Scenario 1 (5.693 m$/year) and in Scenario 7 (4.690 m$/year) and decreased in Scenario 16 (13.2 m$/year). Company experts argued that, these findings could also be expected in real life when scenarios were evaluated; however, the measure of "number of newly awarded projects" should also be taken in account when evaluating the revenues gained per scenario. Thus, it was observed that the "average number of newly awarded projects per year" was not considerably varied among scenarios such that in Baseline, Scenario 1, and Scenario 7, the Company may expect eight newly awarded projects per year, based on the findings of the model. However; in Scenario 16, the model results implied that the Company might not award any new project despite the fact that it targeted budget for new projects or attain new tenders. Thus, the revenue gained in Scenario 16 was the revenue obtained from the current projects of the company. In addition, Company Experts argued that, the differences in the measures of “revenue gained” across scenarios could not be attributed to the number of newly awarded projects; instead, it could be explained by “targeted budget of newly awarded projects”. In other words, although the number of projects operated by the Company would not change, the budget of these projects change based on the external conditions leading to different total amount of revenue gained by the Company. Company Experts added that; it could be expected to award different number of projects under different scenarios, which revealed an improvement area for the forthcoming versions of the model to enhance its behavioral validity.

Gross and Net Profit Margin: Both the gross and net profit margin were varied among scenarios, indeed the results gave some surprising implications to the Company Experts. As also expected in real life; Scenario 1 (gross: 10%, net: 8%) and Scenario 7 (gross: 9% and net: 10%) gave higher profit margins while compared with Baseline Scenario (gross: 7%, net 4%). Company expert surprised that, with their current knowledge and experience, they expected higher profit margins in Scenario 1 while compared with Scenario 7, as Scenario 1 reflected more desirable environment for the companies. After detailed discussions, Company Experts concluded that more desired environmental conditions would have a potential to make competitors to increase their competitiveness or force companies to have more mature resources and capabilities. As given in storylines of Scenario 1, specific focus of companies might be needed to improve their sustainability, technology or human capital as global advancements on these fields grow with maturity of the global/ market environment on PESTBEL conditions. For example, increased power of technology would eventually lead companies to develop novel tools and techniques, integrate automation in construction, which requires companies to advance their resources and capabilities in technology to adapt changes. However, in Scenario Testing, such accumulations or disposals of organizational resources or capabilities were not reflected in the model (input values defined for RCs were remained same). Thus under the same RC conditions, Company may not obtain higher profit margins when business environment get more competitive (as exemplified in Scenario 1). Company Experts concluded that, they could truly benefit from the desirable environmental conditions when they could adapt their resources and capabilities for the global advancements to enhance their competitive advantage over rivals.

Newly Awarded Projects and Tendering performance: Except Scenario 16, tendering performance was remained same among Baseline, Scenario 1 and Scenario 7 (43%). As the Company could not win any new projects in Scenario 16, its tendering performance was generated as “zero” in accordance. Company Experts first discussed that; they may expect different tendering performance for different scenarios. Later, they argued that, although numbers of projects won remain same across scenarios, the budget/ contract amount of these projects were varied depending on conditions of each scenario.

8.3. STRATEGIC OPTIONS TESTING

Incorporation of the dynamic nature of strategies via SD, have potential to inform strategic decision, as strategies might be formed as a result of actions, which may not necessarily have been intended [86]. The aim of Strategic Options Testing was to test different strategies under similar environmental conditions to understand probable implications of these strategies in performance measures. This test was also aimed to enhance the quality of decisions made by making clear of dynamic behavior of the strategies, training in strategy making and supporting actual process of strategy making [53]. Through conducting Strategic Options Testing, it waas aimed to understand whether dynamic strategy maps combined with simulations have potential to provide a notion of a 'test drive' of strategic decisions [61].

8.3.1. Methodology of Strategic Options Testing

Strategic Options Testing was conducted with the Company CEO in Session 8. The underlying methodology of the Session 8 is given in Table 62: Strategic Options Testing SessionTable 62. The testing procedure consisted of three main steps; namely, 1) identification of the strategic options, 2) identification of the input values, and 3) analysis on the outputs generated.

Step 1: Identification of the Strategic Options: The Company CEO identified three strategies in order to be tested via the Computerized Model. As given in Table 63 , the Company CEO was responsible from translating the strategic objectives of the Company to the operational levels. He was also responsible from ensuring the strategic alignment of the company to the objectives set previously. Thus, it was accepted that, he could successfully analyze the findings of the test and ensure behavioral validity of the discussions made. To select the strategic options to be tested, the SMS as well as SOT, developed in Chapter 5, were utilized to support the decision-making process of the Company CEO. He selected following three strategies to test;

- Strategy 1: Improve Human and Technology Capital
- Strategy 2: Focus on Stakeholder Satisfaction
- Strategy 3: Improve Project Management Skills

Step 2: Identification of Input Values: Input values were decided by the Company CEO in Session 8. These values were assigned to variables representing the resources nd capabilities of the Company. For example; in Strategy 1, RCs associated with the "Human and Technology Capital" were set to the value "5". Similarly, RCs given in the Stakeholder Perspective as well as Compliance and Governance Perspective were set to the value "5" in Strategy 2, RC's given in the Project Management Perspective as well as Sustainability Perspective were set to the value "5" in Strategy 3. The idea behind assigning associated RC values as five is that; it was accepted that the company strives for highest level of RC in strategies it premised.

Baseline Scenario given in Scenario Testing, which reflects current external and internal conditions of the Company, was also maintained in Strategic Options Testing as Baseline Strategy. It was used for similar purpose with the purpose in Scenario

Testing, which is to compare outputs of the Computerized Model in strategic options tested.

To be noted that, in Strategic Options Testing RC parameters were accepted to change under different strategies. Thus, different from Scenario Testing, values assigned to the other input parameters of the Computerized Model (such as initial and GM parameters) were remained same with the values assigned to them in Baseline Strategy.

Step 3: Analysis and Comparison of the Outputs Generated: The model was simulated three times for the three different strategies by changing the values of RC parameters. The simulation practice was also undertaken in Session 8. After the results were obtained, they were compared with each other, discussed in detail in order to select the best strategy for the Company. The discussions were also made with the Company CEO in Session 8.

Table 62: Strategic Options Testing Session

Session 8: Strategic Options Testing	
General Information	
Session Topic	Strategic Options Testing
Session Type	Testing and Discussion
Session Targets	• Defining values for input parameters of three strategies • Obtain feedbacks of the Company CEO on structural and behavioral validity of the model under three different strategies
Session Duration	2 hours without any break
Participant Composition	
Size and composition	Top Management: Company CEO
Management Support	Direct support: Workshop attendance and open conversation
Pre-Meeting Interviews	Pre-meeting interviews were not scheduled.
Session Procedure	
Pre-Session Study	• Conducting initial simulations via semi-hypothetical initial values • Analysis of the results by the researcher
Session Input	• Key Outputs for the Baseline Strategy • Strategy Map Structure (SMS) • Strategic Objectives Taxonomy (SOT)
Session Agenda & Methodology	• Reviewing, examining and discussing key outputs of the Baseline Strategy • Obtaining feedbacks about the key outputs, analysis of the structural and behavioral validity of the model under three strategic options
Post-Session Study	No

Plenary Sessions	Verbal statements were recorded to maintain opinions of Company CEO. These statements were utilized when making discussions about current strengths and limitations of the model and recommendations for further researchers.
Session Output	Three simulation results for three different strategies
Methodology, Tools and Facilitation Aspects	
Tools and Techniques	Group Brainstorming, Stella Architecture (SD tool)
Facilitators and their roles	Researcher was the facilitator. She opened dialogues, directed the session and interactively reflected the opinions of participants. Researcher did not add or reject any opinion proposed by Company CEO.
Risks & Limitations	**Risk 24:** Difficulties in adapting "systems thinking", difficulties in understanding model formulations and "Stella Architecture", despite the training session. **Risk 25:** Difficulties in assigning initial values, especially those that require subjective judgements. **Risk 26:** Difficulties in interpreting the model outputs, not trusting the simulation results. **Risk 27:** Confusion in comparing simulation results and real-life behavior as the model gives predictive results about future
Anonymity & Permissions	Although the company allowed to publish assessment and formulation results, they did not permitted to directly give real/ original initial values as they reflected the real financial, human resources and other data. Thus, some manipulations were made in original values, however the underlying theory and simulation results remained same.

8.3.2. Findings of Strategic Options Testing

Similar to the Scenario Testing, due to space limitations, the detailed discussions are given for only the measures those selected as “key outputs” by the researcher. However, as expected in real life behavior, in all strategies tested, the values of key outputs were improved while compared with the Baseline Strategy. The detailed findings are given in Appendix 13.

Contract Profit Margin: Contract profit margin did not changed considerably in different strategies. At first, Company Experts claimed that different contract profit margins might be expected for different strategies. However, researcher explained that, contract profit margin was calculated based on the attractiveness of the national and international construction market, which was determined by the PESTBEL factors. As during the Strategic Options Testing, only the RC factors were tested remaining PESTBEL factors same with the baseline, thus as was expected similar results were obtained for the “profit margin” under different strategic options tested. This explanation was accepted by the Company Experts by adding that, in real life, profit margins do not change based on resources or capabilities. What is change under different RC or strategic options is the contract markup, which was calculated by adding contingency to the contract profit margin. The level of contingency is the parameter that if is affected by strength of the Company in its resources or capabilities (i.e. project management skills, experience in client) as well as by its strategic objectives (i.e. improving risk management skills).

Targeted Budget of Potential Projects: Targeted budget of potential national and international Projects were slightly increased in Strategy 2 (120 m$/ project) while compared with baseline strategy (99 m$/project), Strategy 1 (99 m$/project) and strategy 3 (103 m$/project). As discussed with the Company CEO, the results mplified that, the company might target higher budgets when it ensures stakeholder satisfactions, especially client's. He also argued that while three strategic options were compared in real life, targeted budget for potential projects could be obtained highest when they focus on stakeholder satisfaction. The results also implied that, a lesser project budget would be obtained when company prefers to focus on PM skills as well as this project budget would also be higher than when the focus of the company is solely on improving human and technology capital.

Shareholder Revenue: In line with the increase in the targeted budget of potential projects, yearly shareholder revenue was considerably increased in Strategy 2 (4.854 m$/year) while compared with baseline strategy (3.579 m$/year). This slight increase was also obtained in Strategy 3 (3.871 m$/year) and Strategy 1 (3.647 m$/year). Although targeted budget of potential projects were not changed while strategy 1 and baseline strategy are compared, this change in amount of yearly shareholder revenues was contributed to the improved cost management performance through improved human and technology capital in Strategy 1. For example; while cost overrun was estimated as 13% in baseline strategy, it was decreased to 6%, which might be contributed to strategy taken; improving human and technology capital. Thus, improved cost performance also improved the revenue the company gained in Strategy 1 while compared with baseline strategy.

Gross and Net Profit Margin: In Strategy 3, net and gross profit margin were same with the baseline strategy (net: 4%, gross: 7%). However, they were increased considerably in Strategy 1 (net: 9%, gross: 11%) and Strategy 2 (net: 7%, gross: 11%). Although yearly shareholder revenue was higher in Strategy 2 (4.854 m$/year) while compared with Strategy 1(3.647 m$/year), it was observed that net profit margin was higher in Strategy 1 (9%) when compared with Strategy 2 (7%). Company Experts discussed that, although satisfaction of client and other stakeholders was critical to increase revenue, it might not solely sufficient to increase net profit margin. As given in Strategy 1 (net: 9%), when human and technology capital was improved, net profit margin would get higher. However, when amount of net profit was compared, it was observed that net profit was higher in Strategy 2 (363 m$/year) while compared with Strategy 1 (328 m$/year). Company CEO discussed the findings of Strategy 1 and Strategy 2 about net profit amount and net profit margin in detail and agreed upon the two behavior of the model by claiming that they had potential to reflect real life behavior. He argued that; first, improved client satisfaction would increase the number of newly awarded projects, which in turn improves revenues gained, lead to gaining much more net profit. However, to increase the net profit margin, the Company should do more, such that decreasing expenses (i.e. G&A expenses while also increasing revenue. That kind of success in decreasing expenses is more related with the improving soft skills of the Company such as improving its human capital or employing more skilled employees, all of which enable to reduce costs in the longer time horizons.

Newly Awarded Projects and Tendering performance: Tendering performance was nearly same in (43% in Baseline and Strategy 1, and 45% in Strategy 3) the whole strategies, except Strategy 2 (52%). Company CEO argued that; although it is more difficult to award new projects in Strategy 2, tendering performance of the company still gets high in Strategy 2 as the targeted budget of potential projects will get higher in Strategy 2 (120 m$/ project). He concluded that; in real life, same behavior would be obtained as in Strategy 2 that is the focus of the Company on awarding more projects through improved client satisfaction will improves tendering performance.

Cost Overrun: Cost overrun percentage was lower than baseline strategy (13%) in the all strategies as expected. In Strategy 1 (6%) and Strategy 2 (7%), cost overrun was lowered to the half of the baseline strategy. In addition, in Strategy 3, cost overrun was lowered 1% ending up in 12%, while compared with baseline strategy. Company CEO argued that, he expected much lower cost overrun in Strategy 3 in real life as the focus of the Strategy 3 was on improving project management skills, which was one of the most important skills in reducing probable cost overrun. However, he agreed upon the cost overrun reductions obtained in Strategy 1 and Strategy 2. The results also showed that, investment of human capital (Strategy 1) would lead better cost performance at the end while compared with focus on stakeholder (Strategy 2). This result surprised the Company CEO, however; he argued that thi was also the case in real life and they might change the point of view in their real life strategic decision.

Total Number of Employees: Number of employees were remained same in Strategy 1 (28.824 employees) and Strategy 3 (29.234 employees) while compared with baseline strategy (28.811 employees). However, in Strategy 2 (32.902 employees) approximately 3000 additional employees were required due to higher number of newly awarded projects. Such that, yearly average number of newly awarded projects for baseline strategy, Strategy 1 and Strategy 3 were 7 projects/ year, while this number increased to average 8 project/year in Strategy 2.

Competitive Advantage: Competitive advantage was remained same in Strategy 1 (2,8 out of 5) while compared with Baseline Strategy (2,8 out of 5). However, the rating of competitive advantage of company was increased in Strategy 3 (3,1 out of 5) and get highest value in Strategy 2 (4,5 out of 5). Company CEO argued that, in real life, it was also expected to have highest competitive advantage when the expectations of all stakeholders were fully ensured. He added that, as the company operates in construction industry it is also reasonable to have second highest competitive advantage when the focus on improvement of PM skills. He also discussed that, the findings of competitive advantage also revealed that company should also invest on human and technology capital in order to increase competitive advantage.

8.4. DISCUSSIONS ON SIMULATION TESTS

At the end of the simulation tests, Company CEO and other C-level executives were asked about their simulation exercise in order to understand whether simulations were helpful to enhance quality of decisions they made. Their verbal statements captured as well as observations of the researcher during these sessions revealed that, conducting simulations through dynamic SM have high potential to support their strategic decision making process. Although some further improvements were also needed to enhance the structural and behavioral validity of the model, it was still helpful to decide on organizational strategy and test it from diverse scenarios. These rooms for improvement were discussed in when giving findings of each test and when drawing overall limitations of the research in Chapter 9. Nevertheless, simulation tests provided five major benefits for company experts.

First, Strategic Option Testing supported decision-making process of Company CEO by providing to test implication of different strategic options. For example; while results of three tested strategies were compared, Company CEO eliminated Strategy 3 at first. He claimed that, although competitive advantage could be increased at most, when strategic direction of the Company would be focused on improving stakeholder satisfaction (Strategy 2), this direction might not be sufficient to enhance financial measures of the Company. Such that, tendering performance, revenue gained or profit margin were not changed considerably while compared with Baseline Strategy. He argued that, if both Strategy 1 (improving human and technology capital) and Strategy 2 (focus on client satisfaction) were premised, the results would be better. As discussed in findings of “Gross and Net Profit Margin”, while focus on client satisfaction would be helpful to improve revenue gained and total amount of net profit, improving human and technology capital would enable to decrease G&A costs leading to improve net profit margin. Thus, he concluded that investment on human and technology capital as well as focus on stakeholders would lead to benefits in different fields, thus it might be beneficial to premise both strategies in real life.

Second, both Strategic Options Testing and Scenario Testing made Company Experts to change their way of strategic thinking. For example, in Strategic Options Testing, the results of cost overrun showed that, investment of human capital (Strategy 1) would lead better cost performance at the end while compared with focus on stakeholder (Strategy 2). This result surprised the Company CEO at first; but then he changed his point of view and concluded that kind of change might also be expected in real life. Another example from Scenario Testing also revealed similar change in “thinking routines” and “cognitive biases” of decision makers. As discussed in findings of “Gross and Profit Margin”, Company Experts expected higher profit margins in Scenario 1, which reflected the most desirable future conditions. However, the results showed that profit margin was higher in Scenario 7 (that was more likely to today’s business environment). After detailed discussions, Company Experts concluded that more desired environmental conditions have potential to make competitors to increase their competitiveness or force companies to have more mature resources and capabilities. Thus, expecting higher profit margins in line with the advancements in external environment might be misleading, as Company should also strive for best to catch up advances in external environment by improving its own resources and capabilities.

Third, Strategic Options Testing enabled Company CEO to explore the most optimal strategy by testing different strategies and evaluating associated outcomes. For example, if the Company is striving for maximizing its competitive advantage, then it is beneficial to focus on stakeholder satisfaction. However, if the company is aiming to minimize its cost overrun, then it is needed to improve its human and technology capital. Thus, the findings of the Strategic Options Testing revealed that, the model could successfully be used for "what-if" analysis for different strategic options and their consequent implications on performance measures.

Fourth, both the Strategic Options Testing and Scenario Testing provided to capture the rooms for improvement of the Company. During the Scenario Testing, the simulation exercise boosted self-reflection and elaboration of the Company to envision how the organization would behave under changing future trends and uncertainties. It provided Company Experts to understand strengths and weaknesses of the Company under different future scenarios. For example, Scenario 7 revealed that, the Company might enhance its competitive advantage in order to alter its competitors who were also doing business in a desirable environment. Unless otherwise, their strengths might not be adequate to award new projects, as the external environment was also beneficial for its competitors. In addition, Strategic Options Testing itself contributed to provide a ground for organizational change. It provided to analyze the contribution of each resource and capabilities for the achievement to the overall strategy. Thus, at the end of Strategic Options Testing, Company CEO understood for which resource/ capability the Company should invest on in order to achieve a pre-defined strategy.

Finally, the simulation exercise provided company experts to ask some set of strategic questions, to themselves during the testing sessions. These questions were helpful as they encouraged group thinking, which in turn provided to make better decisions via incorporation of individual mental models. Based on observations of the researcher regarding the discussions of company experts during the sessions, a process was developed as depicted in Figure 26. It represents the strategic decision making process via using dynamic SM model. It exemplifies some set of questions asked by Company experts during group thinking via classifying them in different steps of SPMP. As proposed in Chapter 5, SPMP includes four steps, namely 1) Strategic Position, 2) Strategy Formulation, 3) Strategy Implementation and 4) Strategy Testing. It is expected that, the process depicted in Figure 26 is helpful to structure group thinking or individual decision making in a sound basis.

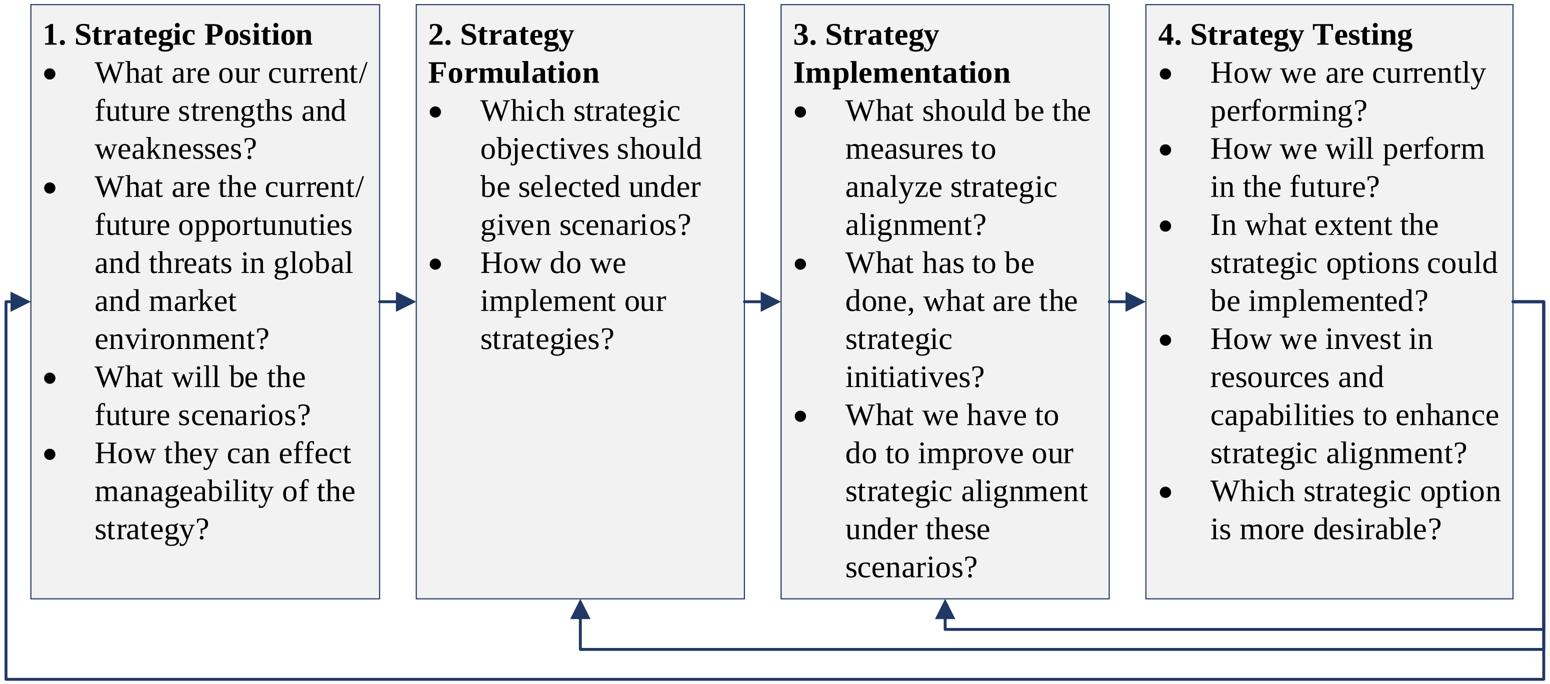


Figure 26: Strategic Decision Making Process with Dynamic Strategy Mapping

Table 63: Detailed Overview on the C-Level Executives Participated in Testing Sessions

ID	Position	Background Information & Role in the Company	Contribution to the Testing Sessions
1	Chief Executive Officer	• Has a major in “Finance” • Works in the company more than 15 years • Primarily responsible from execution of the organizational strategies • Manages diverse corporate services/ departments • Ensures synergies across diverse operational business units • Has specific interest on strategic management, human capital development, business development, new markets and strategic initiatives	• Provides to test diverse strategic options • Interprets the results of the Strategic Options Testing and successfully compares them with the real life
2	Chief Information Officer	• Has a major in “Computer Engineering” • Works in the company more than 10 years • Primarily responsible from implementation of IT infrastructure of the Company • Manages IT-based R&D Projects of the Company • Ensures the use of latest technologies in the operations • Has specific interest on novel technologies, systems, innovation	• Provides to test diverse scenarios and its implications to the organizational performance • Interprets the effect of performance of technology capital to other strategic objectives
3	Chief Financial Officer	• Has a major in “Finance” • Works in the company more than 7 years • Primarily responsible from financing the projects, managing company assets, cash • Controls and approves financial reports (i.e. IFRS) of the Company • Ensures availability of financial resources and repayment of debts • Has specific interest on project financing, financial reporting, treasury, corporate governance	• Provides to test diverse scenarios and its implications to the financial performance • Analyses behavioral validity of the model through comparing financial results obtained from different simulation tests and probable real life behavior

4	Chief Operations Officer	• Has a major in "Civil Engineering" • Works in the company more than 10 years • Primarily responsible from execution of projects • Manages diverse projects, manages claims, direct contact with the clients • Ensures projects are in line with the cost, time, quality, HSE requirements • Has specific interest on PM skills, automation in construction, claim management, sustainability	• Provides to test diverse scenarios and its implications to the organizational performance • Provides to test diverse scenarios and its implications to the operational performance (i.e. market and business growth, sustainability, project management) • Analyses behavioral validity of the model through comparing measures from diverse BSC perspectives obtained from different simulation tests and probable real life behavior

CHAPTER 9

RESULTS AND CONCLUSIONS

This chapter draws a conclusion about the research by arguing expected benefits of the dynamic SM model as well as making some recommendations for the future studies. To do so; the chapter starts with an overview about the research to summarize what has been discussed so far within the context of model development. The chapter continues with the features of the model by summarizing its capabilities in the context of SP and PM. This chapter also explores expected benefits from the perspective of contribution to academic knowledge and improving the industry practice. Final section of this chapter reports major limitations as well as challenges faced throughout the research. Finally, the chapter concludes with some recommendations for forthcoming studies about how to improve and enhance the use of such models.

9.1. RESEARCH OVERVIEW

The aim of this research is to develop a dynamic SM model by incorporating scenario analysis and systems thinking to enhance SP and PM practices of the international construction companies. The underlying theory of the research was constructed based on the; a) the principles of Scenario Management proposed by [2] and b) the methodology of SD developed by [4] which wereincorporated with the BSC and SM methods of [76] and [1]. To develop and use such a dynamic strategy map model, this research was conducted under six consecutive phases.

The first phase was about development of the research objectives to overcome the major gaps reported in the available literature on SP and PM. Nine major gaps were explored which were further classified into three groups; 1) Conceptualization Problems, 2) Quantification Problems, and 3) Implementation Problems. Both the research gaps and research objectives were explained in Chapter 3 in detail. Second phase was about explanation of the Research Design, which was shaped based on the objectives of the research. The Research Design explains the SPMP and SDP, which serve as a basis for the dynamic SM model.

Third phase was about development of the Conceptual Model of the dynamic SM model. To do so; six consecutive steps were undertaken. First, a review and content analysis were performed on the construction future literature. Then, PESTBEL-F and RC-F were developed to inherit internal and external positions of the companies into SPMP. As a further effort, PESTBEL-F was facilitated to conduct scenario analysis, the findings of which were utilized when generating scenario-based strategy maps in Scenario Testing (as reported in Chapter 8). Based on the construction future literature, a SOT was developed and utilized to develop a SMS. Finally, a KPI-F was developed based on the reports of the excellence initiative and benchmarking reports. Based on the KPI-F, some set of Company-specific KPIs were selected in a Focus Group Interview Session 3 via some pre-defined KPI attributes.

Fourth phase was about development of the Computerized Model based on the principles of SD. To do so; four consecutive steps were undertaken. First, the process diagram of the Computerized Model was developed in order to structure the formulation and computerization mechanism of the model. Then, model assumptions and boundary conditions were defined as some set of assumptions were needed to develop the model. Company Experts further discussed and validated those model assumptions in a GMB session. As a final step, based on the model assumptions and boundary conditions the SFD of the Computerized Model was developed in Stella Architecture tool.

Fifth phase was about verification and validation of the Computerized Model. To do so; three consecutive steps were undertaken. First, a Model Validation Structure was developed based on available literature on verification and validation techniques offered in SD literature. Based on the Model Validation Structure, some tests were undertaken to ensure both the structural and behavioral validity of the Computerized Model. In this regard; 1) Dimensional Consistency, 2) Boundary-Adequacy Test, 3) Extreme-Conditions Test, 4) Parameter-Verification Test, 5) Behavior Anomaly Test and 6) Assumptions Sensitivity Testing are iteratively conducted. Based on the findings of the tests, some set of modifications were made both in the Conceptual Model and in the Computerized Model. As a final effort, a Face Validity Test was conducted with the Company Experts to capture attitudes and decisions of industry practitioners on preliminary findings of the model.

The final phase was about model simulation utilizing a real case. The phase was conducted in two steps; first, a Scenario Testing was conducted by using three pre-defined scenarios. Three different simulation results were generated from the model those reflect the model behavior under different future conditions. A second test was conducted to understand the use of the Computerized Model when deciding on different strategic options. The Strategic Option Testing was oriented towards the simulation of model behavior under diverse scenarios, but now scenarios reflected changes in international conditions of the Company, that were its resources and capabilities.

9.2.FEATURES OF THE MODEL

Some basic features of the Model are summarized as follows;

1. **Generic PM Framework:** The Model incorporates a PESTBEL-F and an RC-F, which can further be used in BSC in order to incorporate organizational and socio-environmental rooting [32]. Both Frameworks include diverse factors in different dimensions (i.e. political, economic or tangible, intangible) in different levels (i.e. global, market, company or project levels). The model also includes KPIs specific to the construction industry.

2. **Quantification of Bi-Directional Causal Relations:** The Model is capable of quantification of bi-directional relations among performance measures by utilizing SD modelling. Through SD modelling, the dynamic SM can successfully incorporate strategy paths, which reflect bi-directional relations among performance measures rather than solely representing one-way hierarchy.

3. **Measure Aggregation:** The Model quantifies financial indicators of the Company through some set of inputs assigned in both project management and other soft capabilities of the Company. The Computerized Model also enables to quantify qualitative measures those reflect especially soft skills such as employee motivation, company attractiveness, or competitive advantage. With the development of the model in a software environment, both qualitative and quantitative measures can be calculated and aggregated automatically, giving simulation results simply and instantly.

4. **Dynamic Models with Simulations:** SD modelling enables to add "dynamic" characteristic to these traditional maps, which are generally constructed as "static" structures. It provides aggregation, quantification and simulation of non-linear, causal and complex systems of measures. Simulations can be done in real-time, with groups and results can be viewed, further calibrated, revised and simulated again immediately, which makes the modelling experience an iterative and interactive process. With the use of Stella Architecture, the model can easily be converted into an interactive game with an intuitive interface.

5. **Resource and Performance Accumulations:** Through SD modelling, RCs and PESTBEL factors are also incorporated and linked with performance measures. The KPIs and RCs are represented in stock and flows diagrams in SD model which provides resource and performance accumulations through years. The model can also be facilitated for sensitivity analysis, resource optimization or allocation purpose. Sensitivity analysis, optimization, and calibration to data are also largely automated.

6. **Visualization and Communication:** Graphical user interfaces enable modelers to quickly sketch a causal diagram, capturing the feedbacks, stocks and flows, time delays, and nonlinearities they identify. The reports can be generated from the Model those support daily decisions of the industry practitioners. The Interface Window of the model in Stella Architecture tool enables decision makers to visualize complex models within simple and clear dashboards. Thus, visualization of complex SMs will not be further problem in the use of these maps. The Model can also be used as a dashboard to communicate the organizational performance throughout the organization. It can be used track and visualize strategy maps and scorecards. Also, with the capabilities of Stella Architecture tool, diverse scenario inputs and associated outputs can be visualized within a single map, rather than producing several maps for different scenarios.

7. **Historical Database:** Model outputs will behave like a "knowledge asset" for the organizations about their performances. The Computerized Model can successfully store the performance outputs, which can be retrieved when conducting future measurements. These outputs can be used when measuring the future performance by conducting Scenario Testing. Thus, the model can be used as a lessons learned database in which strategic history of the organizations and their past performances are stored. Simulation history can also be stored in the Model, which can be further retrieved to compare results of the diverse simulations. In addition, the model can be used as a decision-support tool to proactively analyze the performances of strategies with the consideration of their past and current strategic positions.

8. **User-Friendliness**: Stella Architecture provides both the development and visualization of SD models in a user-friendly environment. It also supports the modelling practice via providing built-in functions when developing equations, automatic verification and validation tests and visually attractive interfaces to present the simulation results. The model equations can be written using "friendly algebra" given in "built-in functions" so that advanced mathematical training is not necessary. The Model Window enables to create complex and highly interactive models relatively simple procedure thanks to the user-friendly interfaces and functions of the Stella Architecture Tool. The extent of user-friendliness of these tools is highly critical as various scholars reported the implementation problems of the PM tools due to their unfamiliarity to the industry practitioners.

9.3. CONTRIBUTIONS TO LITERATURE

This research expects to contribute to the knowledge of SP and PM literature by offering,

1. A novel methodology for strategy and performance management literature, which incorporates system dynamics, scenario analysis and group model building in SP and PM approaches.
2. A new conceptual model for the construction management literature, which provides sound Balanced Scorecard and Strategy Map Structure.
3. A computerized model, which uses system dynamics for the development, quantification and simulation of Balanced Scorecard and dynamic strategy map.

A Novel Methodology for Strategy and Performance Management Literature

This research argues that, a novel PM method or a model are needed, which overcomes major limitations reported in literature, in order to enhance SP and PM practices of the industry. In this regard, it suggests the use of SD modelling and scenario analysis for strategic performance management practices by also providing an example from Turkish international construction industry. SD modeling enables to solve non-linearity, complexity and causality problems in PM, reported in current literature. With

SD Modelling, dynamic strategy maps can be successfully produced that automatically aggregates, quantifies, and simulates these maps.

This research incorporates scenario analysis to strategic planning to make it as a collective learning tool [56]. To do so, based on the study of [2], this research provides a theoretical basis for a "thinking philosophy" by incorporating systems thinking, future-open thinking and strategic thinking when developing "future scorecards" of organizations. Through premising these "thinking philosophies", this research provides a methodology for how to develop dynamic strategy maps and future scorecards which can successfully respond the changes occurred in the business environment as well as systematically solve complex, nonlinear and dynamic strategic decisions of real life. Dynamic strategy maps combined with scenario testing provide a notion of a 'test drive' of strategic decisions [61]. The methodology offered can be helpful for scholars, who need for explicit and process-based descriptions about how to manage strategic uncertainty [54] as well as how to predict future trends and developments, particularly in the turbulent business climate [2].

In addition, this research provides an example for how to incorporate Group Model Building in SD modelling to mitigate with the subjectivity involved in decision-making due to cognitive biases of the decision makers. With employing serial and structured Group Model Building sessions, this research expects to provide a link between the use of strategy map and decision-making process to overcome making arbitrary interpretations, which depends on individual mental models, when correlating measures or map elements [52]. Group Model Building provides to capture different mental models of diverse experts in a single and quick workshop sessions. It provides brainstorming and collective learning of decision makers as well as knowledge elicitation, and group consensus needed for strategic decisions made in organizations. Incorporation of GMB with SD modelling provides to transform the separate, unstructured decision of experts into a structured, computerized, validated and collectively developed PM tool. It enables to build the model for its intended purpose, to produce right model behavior for the right purposes [308] by incorporating decision rules during the model development.

This research also suggests a novel process to incorporate SP with system dynamics in a structured manner. To do so, this research uses a System Dynamics Process which also includes four steps, 1) Conceptualization, 2) Formulation, 3) Testing, and 4) Simulation. In addition, as depicted in Figure 4, a Strategic Performance Management Process was developed based on the work of [53], which describes how to conduct SP and PM with using such SD-models. The process suggests a four step approach namely, 1) Strategic Positioning, 2) Strategy Formulation, 3) Strategy Implementation and 4) Strategy Testing. The combination of SPMP and SDP might be helpful for scholars who seek for a systematic and a structured methodology for how to run strategic performance management by using SD-based dynamic strategy maps.

A New Conceptual Model for the Construction Management Literature

The model provides a strategic positioning framework for the construction literature that contains some set of external and internal factors. To reflect external environment conditions, the model proposes a PESTBEL-F, which reflects political, economic, social, technological, environmental and legal developments in the global and construction market. In addition, the model offers a RC-F in which various internal factors are given such as human, organizational, financial resource and capabilities of the construction companies. Scholars, who aim to investigate probable factors affecting construction organizations or understand strategic positions of them, can use these two frameworks.

The model also provides a Strategic Objectives Taxonomy (SOT), which was developed by an in-depth review on theoretical construction future studies. Scholars, who aim to explore probable strategies of construction industry, can use SOT as a basis. It provides a structured list of strategic themes and associated objectives that are widely suggested in available literature. Based on strategic objectives given in SOT, the model proposes SMS, which also reflects bi-directional relations among these objectives. These relations were defined based on the decisions of Company Experts, thus it may not be generalized for the whole industry. However, it still provides a sound basis, as the experts are from the one of the biggest international construction company of Turkey, which is consistently ranked in ENR top 225 international contractor lists. Thus, it may be expected that, the relations and strategy map itself reflect behavior and decisions of similar international contractors. Scholars, might use the strategy map as a reference point, as well as modify it based on future requirements.

Based on the SMS, the model modifies the original BSC of Kaplan and Norton to the construction industry. To reflect characteristics of the industry, three new perspectives were added to the original BSC, namely, 1) Sustainability, 2) Governance and Compliance, 3) Market and Business Growth. In addition, two perspectives of original BSC were adjusted to the construction industry, such that “Customer Perspective” was modified as “Stakeholder Perspective” as well as “Internal Process Perspective” as “Project Management Perspective”. Scholars, who aim to explore BSC modifications in different industries, or use of BSC in PM practices of the construction companies can utilize scorecard model developed in this study.

In current literature, the methodology for defining and assessing non-financial indicators (i.e. leadership, people, learning) inherent ambiguity due to their qualitative nature [12]. Most measures in construction industry focus primarily on short-term performance, are isolated from accounting and other financial measures and do not link through the financial performance of the firm [168]. This research aims to provide a model that reflects industry-based characteristics in PM via both financial and non-financial measures. In this regard, BSC offered in this study, includes a comprehensive KPI Framework, which was developed based on excellence initiative and benchmarking reports. The framework was designed in a way that, it reflects polarity, measurement method, unit, level or causality (i.e. leading, lagging) of each KPI, separately. These characteristics were also named as “KPI attributes” which were further used as a decision-support tool when defining and selecting a refined final list of KPIs. Scholars, who aim to study performance measurement of construction companies or projects via some set of measures, can use the KPI-F as a generic list.

A Computerized Model Utilizing SD

The model can successfully reflects the bi-directional relations among different perspectives or measures in BSC. Thus, it might be helpful to solve any misunderstandings or ambiguities regarding the representation of cause-effect relations, which are highly reported in current literature [33]. With the computerization of the model, representation or quantification of these causalities is neither a problem, as this problem is highly reported as one of the major reason of failure of BSCs due to representation of causalities among perspectives as too simplistic or uncomprehensive [33]. In addition, the model can successfully solve bi-directional and dynamic causal flows by enabling feedback loops, which can contribute to the problem of relying on single, one-way linear or static dependencies due to automation or quantification limitations ([290], [291], [31], [67], [50], [67]). Thus, the model can provide a basis for scholars who aim to reflect real life non-linear systems through such SD-based models.

With the computerization with SD, the model automatically aggregates diverse measures by cascading down top-level BSC measures into lower levels, or aggregating lower levels to the top-level [39]. Although the aggregation of measures required some model assumption to be set, still the outputs of the model demonstrated that these assumptions have a rational base. The model also enables to balance the strategies through taking the relative importance of the resources and strategies into account. Although this feature was gained by defining some model assumptions, it still provides a means of how to balance strategies or reflect relative importance among diverse measures. The consideration of relative importance among measures is also highly critical especially when targets of different measures conflict with each other or when diverse measures require similar resources or competencies ([33], [34], [35], [36], [37], [29]). Thus, authors, who discussed the struggle of identifying relative importance of and the trade-offs between the BSC measures, can use SD as a basis. However, it might be required to make some in-depth studies to improve the quality of decisions about model assumptions.

The Model also has simulation capabilities to understand dynamic behavior of the strategies and enhance the quality of the decisions made. It provides dynamic strategy maps that enable to understand evolution of strategy over time and accommodate strategic changes ([51], [133], [50]). It offers a basis for scholars, who discussed the need for systems having dynamic and flexible characteristics to reflect probable changes in external and internal environment ([292], [293], [294] and [295]). With its simulation capabilities, the model can portray simulation of performance over a time horizon [177]. It can be used develop and test diverse business scenarios in strategy making. Thus, as argued by [53], the model can be facilitated for training in strategy making or for utilizing in actual process of strategy making. In addition, scholars, who aim to understand the effect of changes, uncertainties and trends in organizational strategies or performance measures [50], can use such dynamic models. As recommended by [133], scholars can make dynamic simulations of benchmarking models and performing what-if analyses by utilizing these dynamic models. As a broader view, as suggested by [50], the model and methodology behind it, might provide a basis for a theory, which is needed to accommodate uncertainties and fuzziness in strategy maps and overcome limitations in prediction of future states.

9.4.POTENTIAL BENEFITS FOR THE INDUSTRY

This research is expected to enhance strategic planning and performance management practices of industry practitioners by facilitating the below tasks within construction companies;

- Formalization of Strategic Performance Management,
- Measurement of Company- Level Performance,
- Computerization of PM Practices,
- Testing Strategic Options and Future Scenarios by Simulations,
- Facilitation of Group Decision-Making.

Formalization of Strategic Performance Management

This research is expected to fulfill the need of construction industry for incorporation of environmental conditions into the PM practices by providing a generic strategic positioning framework. Industry practitioners can use the PESTBEL-F to identify trends, opportunities or threats surrounding their organizations as well as RC-F to consider internal characteristics of their organizations during the SP process. As exemplified in Strategic Option Testing, diverse factors from RC-F were computerized in a way that they effect achievement of strategic objectives through either improving or disposing the strategic capabilities of the companies. In addition, global and market conditions selected from the PESTBEL-F were further utilized as scenario drivers in the Model. They were facilitated to generate scenario-based model outputs with which decision makers understand the model behavior under changing conditions of environment. Thus, by using the Model, decision makers can visualize the strategic positions of their companies prior to the making strategic choices, which help them to make rational decisions about future direction of their companies. In short, the model can be used to understand the effect of organizational and environmental factors on performance measurement and strategic fit.

There are vast amount of studies in current literature about BSC implementation in different business sectors. As suggested by various authors (i.e. [46], [16]), BSCs should be modified based on the country, business or industry where companies operate. This study offers a BSC model and a comprehensive KPI Framework, which were developed based on the available reports of construction excellence and benchmarking initiatives. The Framework covers diverse fields and consists various performance measures those reflect financial growth, market growth, stakeholder satisfaction, sustainability capability, governance and compliance capability, project management, as well as knowledge, technology and human capital of the international construction companies. Industry practitioners, who aim to elaborate performances of their companies in diverse fields, can find a comprehensive and a structured list of KPIs, those gathered from reliable knowledge sources. As also suggested by [133], industry practitioners can find clear and precise distinctions about measures utilized for different project tasks or attributes.

Finally, this research has potential to enhance PM practices of industry practitioners by providing a clear methodology and a formal process. As claimed by [300], in construction industry, project performance is generally assessed on personal experience without a standard of evaluation procedure, leading to two project managers assessing the same project differently using the same data [131]. Thus, with the offered methodology, this problem might be overcome.

Measurement of Company- Level Performance

Most of the PM efforts in construction industry have focused on the measurement of project performances and limited in making corporate-level evaluations (i.e. [40], [41], [42], [43], [6]). In addition; “the cascading and aggregation of measures vertically between the organizational and project levels has not been adequately researched” [12]. This research is expected to fulfill the need of construction industry for a complete measurement system that consider and quantifies both the project and company-level measures ([25], [40], [271]).

The model offered in this study, incorporates diverse performance measures, which were aligned, based on project and corporate level strategies (i.e. contract management, regulatory compliance, creditor satisfaction or reputation). As suggested by [12], the model provides automatic aggregation of measures vertically between the organizational and project levels. Thus, industry practitioners can use the model for measuring performance of diverse strategic objectives those are about project and company-level operations. They can assess performance of their companies as a whole rather than solely focusing on performance of single projects. Evaluation of company-level performance is also expected to help decision makers to understand how their headquarters create value on their own.

Industry practitioners can also use the BSC to assess performance of their organizations in different organizational levels or strategic fields separately, which enables to detect rooms of improvement easily (i.e. least performed projects or least achieved strategic objectives). The Model enables to disaggregate the BSC into sub-scorecards so that companies can analyze strategic objectives separately. They can use the BSC in three different levels, 1) to assess performance of corporate support services separately, 2) to assess performance of both the projects and support services, 3) to assess performance of single projects. Thus, companies having several divisions, which conduct different type of projects, can define their missions and strategies by considering other divisions. This feature can also contribute to solve the aggregation problems of several scorecards into a single corporate-level scorecard [16].

Industry practitioners can also use the BSC to assess performance of their organizations in different strategic fields. The Model enables to disaggregate the BSC into sub-scorecards so that companies can assess performance of their diverse strategic objectives separately. Similar to the example given by the [47], if the goal is to assess performance of a supplier, then the number of defects can be utilized as a performance metric. Although assessment of number of defects has little or no importance to the overall financial performance of the organization (Financial Perspective) or customer retention (Customer Perspective), it has great importance on Stakeholder or Project Management Perspective.

Although internationalization is a crucial research area in the construction industry, current literature focuses highly on either PM in construction (mostly focusing on domestic markets) or internationalization in construction (mostly focus on success of the internationalization process). This limitation necessitates studies exploring how both domestic support and international businesses can contribute to the sustained performance of the whole company [20]. Thus, the model is aimed to cover both the international and national revenue growth, both of which will contribute to the overall competitiveness of firms.

Computerization of Performance Measurement

Numerous authors (i.e. [12], [22], [16], [287], [288], [289], [126], [45]) condemned that current PM models are highly poor in implementation and handling change management when any changes occur after the implementation. The Model is expected to overcome implementation problems of existing performance management methodologies as well as make the change management as an integral part of the implementation process [45]. As also discussed with the Company Experts after the simulation tests, the Model enables instant and live implementation process such that the outcomes of any changes in variables can be seen immediately. It is expected to accommodate the changes in strategic environment with its flexible and dynamic characteristics. Thus, as claimed by [12], a simplified and easier framework developed by Stella Architect is expected to be useful for industry practitioners.

In addition, human cognitive capabilities do not include the ability the intuitively solve complex systems those include high-order and non-linear differential equations. As discussed by [298], to formulate a PM problem subjectively, decision makers need to understand context and relations among these measures, which is hard for a human to handle complexity and assess measures analytically. This phenomenon results in poor and highly simplified judgements about systems tending to exclude site effects, feedback processes, delays and other elements of dynamic complexity [67]. As the model was fully automated and computerized, high-order or non-linear problems of real life complex systems can simply be solved by the model. With providing objective and computational procedure via the Computerized Model, decision makers may not spend time to think about how to handle this complexity and search for solutions [299]. Thus, industry practitioners can focus on the improvement of strategic decisions made, rather than wasting their effort on mathematical calculations of complex systems of measures. Indeed, these calculations can be made more simply, accurately and in timely manner via using the Computerized Model.

Company Experts proposed that one the major benefit of the Model is its ability to transform their mental models into a set of model equations through some pre-defined model assumptions. They argued that, without such an automation, it would be too hard to transform their qualitative decisions into some quantitative input values, aggregate and measure the outcome of these decisions about performance measures. As also highly discussed in literature, strategic decision-making process is a messy rather than orderly process in which decisions evolves through a complex, non-linear, and fragment process [108]. In such a process, decision makers are generally required to portray a large amount of unstructured, complex and often conflicting information [469] in dynamic, uncertain, highly constrained timeframes, and real time environments [240]. Thus, as also discussed by the Company Experts, these strategic decisions are generally not easily modelled, quantified or analyzed ([470], [471]).

Testing Strategic Options and Future Scenarios by Simulations

Incorporation of the dynamic nature of strategies via SD is also aimed to inform strategic decision as strategies might be formed as a result of actions, which are not necessarily intended [86]. The model enables decision makers to consider current and future strategic position of their companies when making strategic choices as well as to test and formulate strategies through diverse simulations.

The Strategic Options Testing conducted with the Company Experts revealed that, the Model could be helpful to enhance the quality of decisions made by making clear of dynamic behavior of the strategies, training in strategy making and supporting actual process of strategy making [53]. It provides to evaluate the risk/return of each strategic option with the consideration of uncertainties. Testing hypotheses about strategic options can also improve understanding about system behavior. Thus, industry practitioners may use similar dynamic strategy maps combined with scenario testing which provide a notion of a ‘test drive’ of strategic decisions [61]. They can make better decisions with the improved understanding of dynamic relationships within a system, and could communicate their ideas in a structured manner. In addition, the model provides strategic feedbacks for the decision maker by its simulation capabilities. With making continuous simulations, new strategic goals can be explored as well as strategic orientations of the companies and strategic alignment among projects can be tested and validated.

The Scenario Testing is also helpful for Company Experts to understand implications of probable future scenarios from today. Strategy maps and scenarios both provide effective means to communicate the present and future strategy of organization. Scenario Testing expands the range of future outcomes with which strategies are developed to be more robust under a variety of future circumstances. Thus, it provides continually enlarging and discussing the range of possibilities, that enables strategic planning as a collective learning tool [56]. As also stressed by [60], the development of scenarios, decision makers can enhance strategic planning by minimizing risk posed by future uncertainties, exploiting the trends and opportunities and maintaining risk within an tolerance level.

Simulation tests are also provided a ground for change. It was understood that, they have potential to boost self-reflection and make organizations to envision how they behave under probable future trends and uncertainties with its current resources and capabilities. The results of these tests can make organizations to assess robustness of their core resources and competencies and understand rooms for improvement. Performance measurement outcomes will behave like a "knowledge asset" for measurement of forthcoming years so that the knowledge of these outcomes could be facilitated as a continuous improvement tool.

Simulation tests with SD modeling may also be helpful to support improving revenues or decreasing expenses. For example, a company-specific study conducted by [472] revealed that utilizing System Dynamics in Project management helped Fluor Corporation, a large construction company, to gain business profit of more than $800 million since 2005. Another earlier study conducted by [473] reported that a company named Litton Industries, Inc. (Litton) gained between $170-350 million from the use of SD [474].

Nevertheless, the findings of this research revealed that industry practitioners could use simulation capabilities of SD models as,

- A mechanism for what-if analyses about strategic options under uncertainties,
- A mechanism for sensitivity testing to analyze most sensitive measures to probable changes in internal or external environment of organizations
- A decision support tool to generate better strategic options,
- A collective learning tool that communicates cross-impacts of strategic options across different organizational levels,
- An early warning signal for implications of probable future scenarios and robustness of the organizational resources and capabilities under these scenarios,
- A vehicle for continuous improvement by capturing self-reflection.

Thus, industry practitioners may use this research, those aim to explore the behavior of organizations under different scenarios or analyze future performance of their organizations from today.

Facilitation of Group Decision-Making

The studies of [296] and [297] provide evidence of bias and conflict involved when evaluating performances of companies those adopted the BSC. For example, [297] observed significant conflict and tension between top and middle management about the results of BSC-based PM in an international manufacturing company. Authors experimented that, managers perceived BSC measures as inaccurate and subjective, elaborated their PM practice in a manner of top-down hierarchy instead of participative communication, and used inappropriate benchmarks as evaluation basis.

In addition, the efforts for incorporation of scenario analysis and strategy maps require participation of several stakeholder groups. The participation of these groups enable the comparison and embodiment of various mental models and inter subjective agreements in strategic decision-making. This could generate better strategic options as well as increase the validity and robustness of the organizational strategies with strengthening strategic thinking capability of individual mental models.

This research used a structured GMB methodology about how to develop and use dynamic strategy maps. The findings of this research revealed that, the GMB sessions conducted with the Company Experts improved their understanding about strategies, their causalities and implementation ways. These sessions were also helpful to communicate various fields of strategies with experts having different organizational responsibilities. They also provided a mechanism to decrease cognitive biases through transforming individual mental models into a group thinking and modelling exercise. Thus, this research can provide a mechanism to support and guide management decisions [45], to overcome the risk of confusion, poor implementation and misinterpretation of current PM methods.

9.5. RESEARCH LIMITATIONS AND RECOMMENDATIONS

Generalization: The Model represents the parameters, which are significant, and adequate for the Company, and may not be generalized for other Companies without making adjustments. For example, the development and selection of the KPIs under seven BSC perspectives were based on cognitive decisions of the Company Experts, thus selected KPIs reflect the measures appropriate for the Company. When applying the KPIs or any other measures in other companies, appropriate adjustments need to be made based on the characteristics of the companies. Such that, the Model proposed in this study was developed for a one of the largest Turkish contractor doing business mainly in Russian and European construction markets. Thus, in order to generalize the model, it should be revised for other contractors, which do business in other markets, which are small or medium-sized, or which undertakes different business strategies. Still, the model proposed in this study can be taken as basis for international contractors.

Subjectivity: Although various well-known and internationally accepted reports (i.e. construction future reports of EU, reports of benchmarking and excellence initiatives) of the industry were utilized in model development, the final model was still based on cognitive models of Company Experts. During the selection of model parameters (i.e. KPI), as well as model assumptions, some GMB Sessions were conducted in which judgement, experience, knowledge or intuition of the Company Experts were highly facilitated. Thus, more research can be conducted to find the most applicable and adequate parameters to be modelled. To do this, future studies might focus on identification of “best” parameters for the industry through making some set of questionnaires or collaborative workshops including experts from diverse companies, from different markets or having different sizes as well as from diverse cultural and educational backgrounds. So that, the final parameters selected from such studies can reveal parameters that are applicable throughout the whole industry.

Complexity: The model was based on limited indicators as well as some set of model assumptions were defined to simplify the modelling and computerization process. For example; Company Experts selected KPIs more than the KPIs included in the model in Session 3, however; during the modelling process it was understood that it is difficult to model such a number of KPIs. Thus, KPIs interpreting strategies about governance, compliance and sustainability were remained limited in number and context in the Model. Thus in order to include more number of KPIS, rather than modelling and aggregating all KPIs in a single BSC model, scholars might prefer to develop separate BSC models for each BSC perspective, aggregate KPIs included in each perspective separately, and then aggregate these perspectives in a final Model. In addition, the Model ignores probable interdependencies among projects again due to the simplification purposes. However, resources of diverse projects can be dependent to each other in real life, so resources might be allocated based on the requirements and dependencies of each project. Thus, further researchers might incorporate a portfolio analysis approach in order to develop structurally more accurate and behaviorally more valid models.

Usability: Both the SD methodology and, Stella Architecture Tool itself, simplifies the process of developing and implementing complex and highly interactive strategy setting and PM practices. Although the implementation problems of the current PM approaches was highly solved by using SD, there remains two risks regarding the use of such a Computerized Model based on SD. First, unfamiliarity with the SD modeling is one of the major risks about model use. As it is a novel concept especially for the construction industry, it may lead to prejudice about the easiness and user-friendliness of the models. Second, the evaluation of input measures given in the Computerized Model requires considerable time and effort. As the model requires excessive amount and type of input data, data availability, time to evaluate or reliance on subjective judgements might be limitations for the model use. Thus, future studies may focus on making the PM process easier for decision makers by enabling some supporting tools or methods. These can be about automated systems to collect data prior to the assessment process as well as retrieving them and making available to decision makers during the assessment time. In addition, online training sessions or videos can be provided to decision makers to enhance their familiarity with SD knowledge.

Manipulation: The model requires some set of input values those are defined by model users, in our case, Company Experts. As was stated by one of the Company Experts in Face Validity Test, it is probable to manipulate the model results through defining the input values as a desired state. Some control mechanisms are needed to detect that kind of manipulations in the input values or provide warnings about the manipulations. This may be achieved when historical data for both input and output parameters are defined and stored in the model, which are further retrieved and re-used when input values are defined for new simulation models. The input values of the retrieved historical data might be re-used to make some kind of similarity assessments, variance analysis or sensitivity analysis with the input values of new models. So that; any variance in input and output values among historical data and current models can be automatically detected and further checked by the model developers or users in order to understand the reason of variance (i.e. variance due to manipulation, due to changes in external conditions).

Target Setting: Another limitation of the model is that, it does not provide benchmark results with the best practices or provide effective means of target or standard- setting. Target-setting techniques have been covered in research [475], yet target values are usually negotiated rather than studies ([476], [477]). Although the model automatically quantifies target values based on internal conditions and external environment of the company, it cannot provide benchmarks with the best practices. For example, targeted number of newly awarded projects was automatically calculated by the model based on the competitive advantage of the company, strength of its competitors and attractiveness of the market. Thus, there was no need for Company Experts to negotiate, discuss or subjectively set targets as they could take target values quantified by the model as a baseline. However, the model could not provide a proof of whether same level of target would be defined in real life. Thus, future scholars may focus on identification of how managers could be encouraged to adopt target-and and standard-setting techniques" [12], how these targets could be implemented and generated in such computerized models, or at least test whether the Model produces target values similar to the real-life behavior.

Structural Reliability: Both the verification and validation tests of the model as well as feedbacks of the company experts revealed that, the model successfully reflects internal and external conditions of the organizations, produces dynamic strategy maps based on the diverse future scenarios, considers bi-directional causalities among measures, makes performance simulations, and supports strategic decision making process. Although the validations tests showed that the model was valid enough in structural and behavioral aspects, its underlying methodology stills depends on some model assumptions. For example, due to time limitations of the Company Experts, relative importance weights of KPIs were ignored and assumed as equal. Thus, separate studies can be conducted to capture these weights, especially in circumstances when these weights vary based on their contribution to the different kind of strategies taken. For example, in case the overall strategy of the company is about "sustainability", the perspective associated with the "sustainability" can be expected to have higher weight in measuring the organizational performance. After the same period, the same company might evolve itself through innovation, such that it may target to enhance its sustainability via more innovative processes and products or to cut the administrative costs through research and development. In this case, it is highly probable that the company puts more importance to the perspective of "learning and growth". Thus, scholars who develop or use that kind of models can find a way to define and utilize importance weights among measures in reliable and practical methods. More studies should also be conducted to test the model assumptions or at least these studies should review and modify them based on the requirements of the other companies.

Behavioral Reliability: Behavioral reliability of the model was tested by the Company Experts during the Face Validity Test, Scenario Testing and Strategic

Options Testing, as well as the output generated were also compared with the historical financial data of the Company. After these tests, it was ensured that the Model successfully represents behavioral reliability of the Company; however, more tests were still needed to ensure its reliability in other companies. This can be made by making further Face Validity Tests with experts of other companies or making comparisons with historical financial data of these companies. In addition, although quantitative outputs of the model could be tested by historical data comparison (i.e. financial measures), some other outputs representing qualitative measures (i.e. employee motivation) could not be compared with any real-life historical data due to its "soft" nature. Thus, further efforts could be made to capture behavioral reliability of that kind of qualitative measures.

Data Availability: Although the model was tested by some financial data of the Company, some other quantitative or qualitative measures could not be tested due to unavailability of real data. When asked for the Company Experts, the reasons for the data unavailability are reported into three folds. First, some strategies taken by the company ere so new such that there has not been any historical data to collect. Second, Company experts were so sensitive to share the available data due to the data privacy. Finally, there has not been any systematical mechanism available to capture and store data throughout years. Thus, separate studies for data collection can be made in order to capture, review, analyze and retrieve existing data of companies in a structured manner. As the quality of the PM construction projects depends on the quality of the data obtained during project execution, more effort and dedication are needed to develop some kind of "data collection systems" [131]. In addition, historical data represents the past performance of the companies, which provides a reference point to benchmark against and a baseline to measure future performance [478].

The originality of this thesis comes from tailoring scenario analysis and system dynamics to support strategic planning and performance management via dynamic strategy maps. The advantages of the proposed model stem from facilitating mental models of managers and translating them into strategy development in the organizations by also incorporating future thinking and system dynamics. This research is expected to contribute to the literature and industry through offering both a methodology and a model for creating dynamic strategy maps those can successfully reflect the effect of organizational or environmental changes in organizational performance as well as promote strategy making and learning via simulating strategic options of the organizations.

Although there exists some room for improvement, it is believed that this research can provide a sound basis for both industry practitioners and academicians who aim to enhance strategic planning and performance management practices. Although the dynamic strategy map offered in this research, was developed for internatonal construction companies, the "thinking philosophy" and "methodology" premised for development of such a model can also be taken as basis by other industries.

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APPENDIX 1: THEORATICAL BACKGROUND

Table 64: Traditional Intellectual Routes to Strategic Analysis

	Long Range Planning	Structure Conduct Performance	Strategic Conflict	Resource Based View	Core Competence	Knowledge Based View	Dynamic Capabilities
Strategy	Forward Planning. Distant from reality.	Firm Position within industry. Attractiveness of Industry.	Manipulation and influence of firm on other firms and markets through interaction.	Firms are heterogeneous and consist of resources (VRIN) and capabilities (firm specific).	Unique competency—collective knowledge, production skills and technologies.	Knowledge is the inimitable quality.	Rapid changing environments. Adapting, integrating and reconfiguring capabilities.
Lens of Study	Inside-Out	Outside-In	Outside-In	Inside-Out	Inside-Out	Inside-Out	Inside-Out
Purpose	Planning ahead	Competitive positioning	Tactical positioning	Control of resource flows	Protect and exploit USP	Intellectual talent configuration	Assembly or reassembly of skill
Criticisms	Implemented and realised strategy may be different to planned. Time lag due to planning. Suited to predictable environments.	Focus on Industry structure. Static model. Perfect competition will result in equilibrium.	Understanding behaviour of competition. Oligopolistic markets. Focus on rivals. Imperfect information.	Lack of managerial importance. Not suited to unpredictable environments. Can sustained advantage be achieved? How is value defined and what is the nature of SCA?	Off shoot of RBV. Focus on competency as a capability. Value based systems—managerial capability, technical skills. Institutionalised competencies. Core rigidity inhibits innovation.	Off shoot of RBV. Notion of firm as a single community rather than collective individuals. Cost associated to tacitness of knowledge exchange.	Off shoot of RBV. Dynamic capabilities are a prerequisite to CA rather than formula for SCA. Managers have bounded rationality.

Sustained Competitive Advantage	Rational decision making. Environment influence is low. Stable environments.	Based on how firms defend themselves within industry over time. Equilibrium position— entry barriers/ mobility.	How rivals are kept off balance through “playing the game”.	Is based on inimitability. SCA is based on bundle of resources combined with capability. Superior systems and structures.	Portfolio of core competencies (collective learning) provide differentiation and SCA.	Heterogeneous knowledge bases of the firm. Superior efficiency.	Distinctive processes (co-ordinating and combining), paths and position. Dynamic capability where a series of CA results in SCA (hyper-competition).
Concept of Value	Analytics in decision making and predicting.	Privileged industry position.	Privileged market position.	Resources/ bundles of resources and capability. Firm level efficiency.	Core competencies through alliances, skill networks.	Firms as social communities of knowledge. Create knowledge, replicate/transfer and grow.	Schumpeterian innovation. Through exploration and exploitation. Dynamic capability.
Scholarly Support	[8], [11], [256]	[5], [479], [480]	[481], [482], Game Theory	[253], [77], [247], [483]	[258]	[484]	[252]
Performance	Goal focused. Profit. Management’s ability to predict.	Based on entry barriers. Concentration ratios of firms within industry.	Conflict with rivals. Manipulation of information in markets.	Unique resources and capabilities. Improved systems and structures.	Through collective alliances. Focus on core capabilities.	Knowledge is the firm’s strategic resource.	Creative destruction of existing competencies.

APPENDIX 2: PESTBEL AND RC FRAMEWORK

Table 65: The Combined PESTBEL and SWOT Framework

PESTBEL FRAMEWORK				SWOT Framework	
Dimension	**Level**	**ID**	**Factor**	**Opportunities**	**Threats**
Business	Global	BU-1	Market size and growth	1. Construction market is enlarging, 2. Community need for construction outputs	1. Low community need for construction, Slow industry growth
Business	Global	BU-2	New countries and markets	1. Increased globalization, 2. Internationalization is dominant, 3. Market confidence in new business segments	1. High entry barriers, 2. Strict foreign trade regulations, 3. Low engagement in international markets, 4. New business segments are too risky
Business	Market	BU-3	Market trend & maturity	1. Differentiation is necessary, 2. Partnering, JV and framework agreements, 3. Strategic long-term shareholders, 4. Maturity in project management, 5. Governance thinking	1. Projects are based on lowest cost, 2. Low strategic partnerships, 3. Projects are still unpredictable, 4. Improvement efforts are seen as expensive, 5. Fails to meet modern business requirements
Business	Market	BU-4	Power of suppliers and vendors	1. Demand for buyers, 2.Prices can be negotiated	1. Dominated by a small number of companies, 2. Prices cannot be negotiated
Business	Market	BU-5	Power of competitors	Numerous or equally balanced competitors	1. High competition, competitors are flag carriers, 2. Competitors have high brand identification and customer loyalties
Business	Market	BU-6	Barriers to entry	1. No need for differentiation or switching costs, 2. Foreign governments promote globalization in construction	1. High level of capital requirements and switching costs, 2. Governments limit or prevent to entry, 3. High level of learning and experience curve
Business	Market	BU-7	Barriers to exit	1. No specific requirement for exit, 2. Still sustained relations	1. High fixed costs of exit, 2.Government and social restrictions, 3. Damaged strategic interrelationships
Business	Market	BU-8	Client requirements & maturity	1. Based on sustainability, quality, technology, 2. Better evaluation of client needs	1. Based on low cost, 2. Continuously changing requirements

Business	Market	BU-9	Market availability of construction resources	1. Available and efficient material/ equipment, 2. Available and qualified subcontractor/ suppliers	1. Unavailable or poor material/ equipment, 2.Unavailable or unqualified subcontractors/ suppliers
Business	Market	BU-10	Market availability of skilled workforce	1. Educated, skilled workforce, 2. Increased work skills and industrial capacity	Aged skilled workforce, skill shortage
Economic	Global	EC-1	Economic development & growth	1. Maturity of economic legislation and policy statements, 2. Stable/ healthy economic indicators (i.e. inflation, interest and exchange rate), 3. Foreign economic investments, 4. Positive economic growth	1. Immature economic legislation and policy applications, 2. Vulnerable and instable economic indicators (i.e. inflation, interest and exchange rate), 3. Negative economic growth, 4. No foreign investment
Economic	Global	EC-2	Government budget deficit / country debt	Well-being state of economy (financial strength)	1. Falling government revenues, 2. Debt crisis, currency collapse, money volatile
Economic	Global	EC-3	Level of globalization	1. Reduced knowledge boundaries across countries, 2. Promotion of international trade, 3. Increased financial strength with international partnerships	1. Fall behind in globalization efforts, 2. Poor international trading efforts, 3. Host country exposed to sanctions
Economic	Global	EC-4	Income and employment	1. High income, 2. Low unemployment	1. Low income, 2. Falling employment and personnel income
Economic	Market	EC-5	Market economic structure & strength	1. Increased public private partnership, 2. High profit margin, 3. Predictable revenues and expenses	1. Stock/ housing market collapse, 2. Decreased consumption and business profits, 3. Investment in construction is seen as expensive, 4. Expenses are vulnerable and volatile to price changes
Economic	Market	EC-6	Market availability of financial resources	1. Credit/ cash availability from internal creditors/ banks/ sponsors, 2. Governments funds are available	1. No access to finance, 2. Government funds are not available
Economic	Market	EC-7	Regulations specific to construction	1. Regulations are clear and applicable	1. Strict and complex regulations (ie taxation)
Environment	Global	EN-1	Environmental awareness / protection regulations	1. Whole triple bottom line & sustainability culture, 2. Mature and applicable environmental laws and regulations	1. Attention to environment is not sufficient, 2. No specific law / regulations to protect environment, 3. Existing law/regulations are vague or complex
Environment	Global	EN-2	Environmental pollution	1. Pollution is controlled and mitigated	1. Increased pollution, 2. No/ insufficient mitigation actions for pollution

Environment	Global	EN-3	Energy & water scarcity	1. New forms of energy resources are developed, 2. Proper and responsible use of energy & water	1. Increased energy scarcity, 2. Increased water crisis
Environment	Global	EN-3	Ecological balance & preservation	1. Preserved habitat & national resources	1. Failing earth habitats, 2. Existence of natural or man-made eco-disasters, 3. Pandemics: loss of forests, food plants and animals, disease panic
Environment	Global	EN-4	Level of climate change	1. Climate change is under control, 2. Zero carbon footprint, 3. Greenhouse gas emissions are under control	1. Increasing climate change, not controlled, 2. High carbon footprint, 3. High greenhouse gas emissions
Environment	Market	EN-5	Market environmental regulations	1. Effective and applicable environmental regulations, 2. Increasing sensitivity to sustainable development	1. Pollution levels/ climate change demand, 2. Extensive regulation of the industry, 3. Strict laws for land use and construction
Environment	Market	EN-6	Market advancements in environment	1. Novel technologies/ materials to advance sustainability, 2. Self-sufficient zero-energy or even plus-energy communities, solutions	No considerable technological advancements to mitigate with climate change and resource scarcity
Legal	Global	LE-1	Regulatory bodies and processes	1. Certain and fair court decisions, 2. Independent judiciary, 3. Effective regulatory bodies & processes	1. Court decisions subject to preferences of dominant groups, 2. Lengthy and expensive regulatory processes
Legal	Global	LE-2	Maturity of legal system	1. Mature/ stable country laws and regulations, 2. Mature governance and ethics	1. Vague and complex laws and regulations, 2. Changes in law, 3. Existence of corruption, bribes
Legal	Global	LE-3	Compliance with international laws, rules, standards	1. Compliance with international legal framework, 2. Coherence with international diplomacy rules, 3. Support same international organizations	Major compliance problems with international legal framework
Legal	Market	LE-4	Industry regulations about construction	1. Mature/ stable laws and regulations (i.e. tax, fiscal, monetary, industrial, labor/ employment, health& safety, export and import policies)	1. Vague and complex laws and regulations (i.e. tax, fiscal, monetary, industrial, labor/ employment, health& safety, export and import policies), 2. Insufficient laws for partnerships/ joint ventures, 3. Strict requirements (work permits, local partners, local tax)

Legal	Market	LE-5	Claim and litigation system	1. Effective management of claims, disputes, disagreements, conflicts and contract related problems, 2. Effective in enforcement mechanisms	1. Poor management of claims, disputes, disagreements, conflicts and contract related problems, 2. Poor enforcement mechanisms
Political	Global	PO-1	Effectiveness of political system & development	1. Stable and healthy reforms & applications, 2. Stable and healthy reforms & application of government, 3. Successful government policies	Fragmentency of governmental structure
Political	Global	PO-2	Level of political stability	1. Stable political conditions, 2. Sustained social peace	1. Instable & vulnerable government, 2. Poor support for government, 3. High level of riots, protests and demonstrations, 4. Negative declarations of media
Political	Global	PO-3	Level of threats for national security	1. Greater levels of national security, 2. Healty political relations with other countries	1. Increased security crisis, 2. Existence of war, terrorism, organized crime
Political	Global	PO-4	Level of international relations	1. Increased economic collaboration, 2. Increased collaboration through international alliances, 3. Stronger and stable international relations	1. Sanctions from other countries, 2. Poor relations in international alliances, 3. Negative declarations of international media
Political	Market	PO-5	Degree of government intervention in business	1. Government promote business development	1. Government regulations too strict and complex to do business, 2. High level of bureaucracy, 3. Slow permits by governmental departments and agencies
Political	Market	PO-6	Level of international trade and foreign investments	1. Increased globalization of the industry, 2. Success in import and export activities, 3. Increased foreign investments	Import and export restrictions from other countries
Social	Global	SO-1	Social equality & ethics	1. Success in social equality and diversity, 2. No social polarization, 3. Respect for all social classes, 4. Laws& regulations protect human rights, 5. Community awareness and consciousness of rights	1. Increasing social polarization, 2. High level of income inequality, 3. High level of gender inequality, 4. High level of racial/ religion inequality, 5. Poor consciousness about human rights

Social	Global	SO-2	Social crisis	1. Sustained social peace	1. Immigration and Refugee Crisis, 2. High level of nationwide strikes, civil wars, riots, protest and demonstrations
Social	Global	SO-3	Population demographics	1. Younger population, 2. Increasing pattern of birth rate	1. Misalignment of population structure, 2. Aging population
Social	Global	SO-4	Social maturity	1. High level of literacy and education attainment, 2. Role of the women, position, nature of responsibilities in society, 3. Healthy consumer buying patterns, power and willingness	1. Poor literacy and education attainment, 2. Decreased consumption
Social	Market	SO-5	Industry image	1. Better reputation of the industry	Poor image of the industry
Social	Market	SO-6	Employment patterns	1. High women employment, 2. No discrimination in employment	1. Labor market discrimination, 2. Preference from the dominant group in community
Technology	Global	TE-1	Power of technology	1. Increased power of technology, 2. Development of smart communities	Little requirements about technology
Technology	Global	TE-2	Investment in R&D and innovation	1. High level of investment in R&D, 2. Government funds available for R&D	1. No investment in R&D, 2. In-house R&D efforts has fallen
Technology	Market	TE-3	Industry R&D and innovation potential	1. High innovation potential, 2. Increased attention to innovation, 3. Increased power of computers, 4. Clients require novel techniques in projects	1. Low innovation potential, 2. No access to technology, patents and licensing, 3. Clients focus in on cost
Technology	Market	TE-4	Technological trends	1. Use of robotics, 2. Digitization & automation in construction, 3. New material and methods (i.e. Nanomaterials), 4. Shift away from manuel operations to digitization, 5. High level of ICT use, 6. Use of BIM, virtual spaces, 3D and GIS applications	1. No novel technological advancement, 2. Reliance on traditional materials and methods

Table 66: The Combined RC and SWOT Framework

RC Framework				RC Strenght/ Weakness Indicators	
Dimension	**Level**	**ID**	**Factor**	**Strength**	**Weakness**
Management	Project	MN-1	Cost Management Capabilities	1. Accuracy of cost/ budget estimation, 2. Accuracy of quantity take-off and unit costs, 3. Effectiveness of cost estimation method, 4. Performance/ competency of cost estimator, 5. Effectiveness of financial reporting, control and check	1. Inaccurate cost estimation, 2. Inaccurate quantity take-off, unit costs, 3. Wrong selection of cost estimation method, 4. Lack of experience of the cost estimator, 5. Lack of financial control and check, 6. Lack of contingency estimation, 7. Delays in bill payments, 8. Lack of appropriate financial plans, 9. Lack of budget control and reporting, 10. Lack of cost reporting and documentation system
Management	Project	MN-2	Time Management Capabilities	1. Accuracy of estimated activity durations and relations, 2. Availability of scheduling tools and techniques, 3. Effectiveness of schedule control & reporting, 4. Performance/ competency of project scheduler, 5. Completeness of defined activities	1.Poor definition of activities, relations and durations, 2. Lack of scheduling tools and techniques, 3. Lack of schedule control and reporting, 4. Poor judgment and experience of staff, 5. Unrealistic contract duration
Management	Project	MN-3	Scope Management Capabilities	1. Accuracy of definition of project requirements, 2. Effectiveness of project scope definition, 3. Effectiveness of scope control, 4. Effectiveness of scope verification	1. Poor definition of project requirements, 2. Poor definition of project scope, 3. Poor scope verification and control, 4. Vagueness of contract clauses, 5. Poor definition of project scope and objectives, 6. Poor definition of contract terms, 7. Poor definition of roles and responsibilities, 8. Poor declaration of defined project objectives
Management	Project	MN-4	Quality Management Capabilities	1. Availability of company registration with ISO standards, 2. Availability of QAQC policies and procedures, 3. Availability of QAQC management system, 4. Effectiveness of nonconformity control and audits, 5. Effectiveness of QAQC inspection, testing and data analysis	1. Lack of company registration with ISO or other international standards, 2. Lack of company QAQC policies and procedures, 3. Lack of inspection, testing and data analysis, 4. Lack of supplier involvement for QAQC, 5. Lack of nonconformity control and audits

Management	Project	MN-5	Procurement Management Capabilities	1. Availability of procurement strategy and methodology, 2. Competency in material standards and specifications, 3. 'Compliance with taxes, customs, trade and other, 4. Regulations, 5. Effectiveness of logistics (no damage, theft, loss)	1. Inappropriate procurement method utilized 2. Inappropriate service providers / products, 3. Poor supplier relationships management, 4. Failure to identify potential supplier sources, 5. Lack of a preferred supplier list, 6. Inadequate material standards and specifications knowledge, 7. Inaccuracies/information errors in purchase orders
Construction Resources	Project	CR-1	Labor Resources	1. Availability of work permits, 2. Competency of labor skills and capabilities	1. Shortage of skilled labor, 2. Strict requirements to obtain work permits
Construction Resources	Project	CR-2	Material Resources	1. Availability of material manufacture and delivery, 2. Availability of material storage and handling, 3. Quality of purchased products, 4. Correctness of material selection	1. High level of material delivery problems, 2. Poor quality of purchased products, defects in products
Construction Resources	Project	CR-3	Equipment Resources	1. Availability of equipment manufacture and delivery, 2. Availability of equipment spare parts, 3. Availability of machines and equipment, 4. Availability of specialized equipment, 5. Competency of equipment operators, 6. Level of equipment efficiency, 7. Quality of purchased products	1. Delay in the approval/manufacture of equipment, 2. Unskilled operator, 3. High level of equipment delivery problems, 4. Low productivity and efficiency of equipment, 5. Loss of or damage to goods in transit, 6. Poor logistics planning, 7. Poor quality of purchased products, defects in products, 8. Damage or theft of cargo, transferred goods and services
Construction Resources	Project	CR-4	Infrastructure Resources	1. Availability of accommodation facilities, 2. Availability of communication facilities, 3. Availability of heat, power and electricity facilities, 4. Availability of storage and warehouse facilities, 5. Availability of transportation to site, 6. Availability of water supply, 7. Effectiveness of site inspection and control	1. Shortage in water supply, 2. Unavailability of land and air transportation, 3. Unavailability of water transportation, 4. Unavailability of communication, 5. Unavailability of power
Construction Resources	Project	CR-5	Design and Engineering Resources		1. Complexity/errors of plans and specifications, 2. Complexity/errors of shop drawings and samples, 3. Inadequate/ mistakes in geotechnical Investigation

Sustainability	Project	SU-1	Environmental Management	1. Effectiveness of project environmental management system, 2. Existence of environmental audits, 3. Compliance with international laws and certification, 4. Effective prevention of noise, odors, dust and gas emissions, 5. Requirements about saving endangered species, 6. Effectiveness of waste management	1. Lack of environmental management system, 2. Lack of compliance with international laws and certification, 3. Lack of prevention of noise, odors, dust and gas emissions, 4. Lack of compliance to requirements about wastes, 5. Lack of compliance to requirements about endangered species
Sustainability	Project	SU-2	Health and Safety Management	1. Availability of H&S material and equipment, 2. Availability of organizational H&S procedures and standards, 3. Effectiveness of H&S training, audit and inspections, 4. Effectiveness of safety monitoring and reporting, 5. Compliance to international laws and certifications, 6. Level of safety awareness among organization	1. Lack of compliance to requirements about health and safety training, 2. Lack of compliance to requirements about safety monitoring and reporting, 3. Lack of inspection of hazardous/dangerous conditions, 4. Lack of organizational safety procedures and standards, 5. Lack of health and safety material and equipment, 6. Lack of safety awareness among organization, 7. Lack of compliance to ISO, OHSAS, Nebosh certification, 8. Lack of compliance to international laws about health safety protection
Governance & Compliance	Project	GC-1	Contract Management Capabilities	1. Appropriateness of type of contract, 2. Assessment of contractual liability/risks, 3. Availability of claims and dispute resolution method, 4. Clarity of rights, obligations and risk sharing among project parties, 5. Effectiveness/ completeness of contract clauses	1. Inadequate overall contract management system,2. Poor assessment of contractual liability/risks, 3. Lack of contractual policies and guidelines, 4. Ineffectiveness of general terms and conditions in contracts, 5. Lack of standardized contract clauses/formats, 6. Lack of coherence among contract clauses, 7.Poor definition of rights, obligations and risk sharing among project parties, 8. Poor definition of project financing, cost management and budgeting, 9. Poor definition of legalized management procedures, 10. Poor definition of claims and dispute resolution method, 11. Lack of a contractual relationship structure, 12. Inappropriate type of contract

Governance & Compliance	Project	GC-2	Risk Management Capabilities	1. Availability of contingency planning, 2. Availability of risk management system, tools and techniques, 3. Availability of insurances and bonds (bid, payment, surety), 4. Maturity of risk awareness	1. Lack of contingency planning, 2. 'Lack of risk management system, tools and techniques, 3. Lack of risk ownership allocation, 4. Lack of risk training and education, 5. Lack of insurances and bonds
Governance & Compliance	Corporate	GC-3	Corporate Governance Capabilities	1. Success of BoDs and executives in operations, 2. Maturity of Owners or shareholders, 3. Clarity of roles and responsibilities, 4. Compatibility to legislation and regulations, 5. Maturity of anti-trust/ competition management system, 6. Maturity of bribery, fraud, corruption prevention system, 7. Maturity of compliance with code of conduct, 8. Maturity of internal control, audit and ethics system	1. Lack of bribery and corruption avoidance system, 2. Lack of compliance with code of conduct, 3. Lack of fraud prevention system, 4. Lack of anti-trust/ competition management system, 5. Lack of compliance with governance guidelines, 6. Ineffectiveness of ethics system
Governance & Compliance	Corporate	GC-4	Legal Affairs Management	1. Availability of structured dispute resolution method, 2. Adequate overall contract management system, 3. Availability of contractual policies and guidelines, 4. Performance of in-house counsel, 5. Relations with external law firms	1. High amount of risky lawsuits, 2. Lack of structured dispute resolution method, 3. Poor communication and coordination with external law firms, 4. Ineffectiveness of legal opinion made by attorneys, 5. Poor performance of in-house counsel
Technology and Human Capital	Corporate	TE-1	Innovation and R&D Capability	1. R&D spending, 2.'Innovation, R&D and technological capabilities, 3. 'Patents, copyrights, brands and trademarks, 4. Strong patent portfolio	
Technology and Human Capital	Corporate	TE-2	Technological Capability	1. Effectiveness of IT infrastructure, 2. Level of automation and digitization, 3. Maturity of IT security management system, 4. 'Automated systems, tools, software developments	1. Unauthorized configuration items in the IT infrastructure, 2. Poor performance of IT continuity plan

Technology and Human Capital	Corporate	TE-3	Organizational Capital	1. Shared vision, mission and objectives, 2. Organizational culture, values, norms, beliefs and expectations, 3. The formal and informal communication channels, 4. Organizational design and management structure, 5. Internal rules, procedures, policies and methods	1. Complexity of organizational structure, 2. Vagueness of roles and responsibilities, 3. Unrealistic organizational structure and work distribution
Technology and Human Capital	Project	TE-4	Knowledge Management Capabilities	1. Experience in operating in similar countries, 2. Experience in operating under similar market conditions, 3. Experience in operating under similar regulatory framework, 4. Experience in operating with similar client, 5. Experience in similar projects, 6. Organizational learning	Lack of experience in operating in similar countries, 2. Lack of experience in operating under similar market conditions, 3. Lack of Experience in operating under similar regulatory framework, 4. Lack of Experience in operating with similar client, 5. Lack of Experience in similar projects, 6. Organizational learning
Technology and Human Capital	Project	TE-5	Human Capital	1. Availability of career development opportunities, 2. Availability of high talents and skills, 3. Effectiveness of social contribution provided to employees, 4. Level of employee motivation and engagement, 5. Level of staff/ personnel turnover, 6. Maturity of HR management systems (performance, compensation, recruitment, talent, education), 7. Core competencies, skills, knowledge and employee talents	High open time of job positions/ High amount of time to recruit, 2. Low job offer acceptance rate, 3. Lack of a comprehensive and structured recruiting pool, 4. Low talent retention, 5. Low employee engagement, 6. High staff/ personnel turnover, 7. Low motivation of employees, 8. High % of low performing employees, 9. Lack of HR management systems, 10. Poor social contribution provided to employees
Stakeholder	Corporate	ST-1	Relations with Public	1. Availability of annual PR plan and budget, 2. Brand reputation, 3. Effectiveness of corporate digital platforms, 4. Effectiveness of relations with press and media, 5. Effectiveness of social media posts	Ineffectiveness of PR Annual Plan/ Communication Plan, 2. Poor performance of PR campaigns, 3. Wrong/missing information in social media posts, 4. Low number of visitors to corporate digital platforms, 5. Lack of crisis management system, 6. Poor relations with press and media
Stakeholder	Corporate	ST-2	Relations with Creditors	4. Maturity of debt management, 2. Maturity of management of covenants, 3. Effectiveness in payments to lenders and creditors, 4. Availability of funding source from lenders or creditors	1. Lack of compliance with covenants

Stakeholder	Corporate	ST-3	Relations with Regulatory Bodies	1. Compatibility to laws and regulations, 2. Compatibility to tax obligations, 3. Level of bureaucracy, 4. Level of requirement and regulations, 5. Level of inspection and audit, 6. Timeliness of obtaining approvals from authorities	1. Poor compliance with accounting standards and regulations, 2. Lack of standardization among accounting standards and regulations, 3. Lack of compliance with multi country government regulations, 4. Poor adoption to new legisation and regulations, 5. Poor regulatory compliance Uncertainty of tax positions, 6. Lack of compliance with tax obligations Errors in tax calculation, 7. Lack of tax audit/ controls, 8. Delays in filling and paying taxes, 9. Lack of compliance with taxes, customs, trade and other regulations, 10. High amount of tax penalties
Stakeholder	Project	ST-4	Relations with Clients	1. Competency and experience of client organization, 2. Customer preference criteria, 3. Financial strength of client, 4. Level of bureaucracy in client organization, 5. Level of existing customer satisfaction and loyalty, 6. Timeliness of obtaining approvals from authorities	1. Unclear objectives of client, 2. High level of bureaucracy in client organization, 3. Negative attitude of client, 4. Lack of financial resources of client, 5. Managerial incompetency of client, 6. Poor coordination/communication/control management ability, 7. Incompetency in cost management and budgeting, 8. Incompetency in preparation of a project documents, 9. Delays in decision-making, approvals, permits and giving instructions, 10. Poor leadership ability, 11. Poor relations with other stakeholders, 12. Poor relations with government departments and agencies, 13. Poor monitoring and supervision of staff/workers
Stakeholder	Project	ST-5	Relations with Partners	1. Partnerships, joint ventures and alliances.	1. Failure to meet liabilities of partners

Stakeholder	Project	ST-6	Relations with Subcontractors/Suppliers	1. Availability of a preferred supplier list, 2. Availability of payments to subcontractors/ suppliers, 3. Availability of subcontractor/supplier selection procedures, 4. Level of satisfaction from subcontractors/ suppliers, 5. Level of skills and experience of subcontractors, suppliers	1. Delays in payments to subcontractors, 2. Poor technical skills and experience of subcontractors, 3. Poor quality of subcontractors, 4. Poor managerial skills of subcontractors, 5. Low satisfaction level about subcontractors, 6. Delays in the payments of subcontractors, 7. Poor coordination and communication with subcontractors, 8. Failure to comply with the procurement durations specified in procedures/ policies, 9. Poor compliance to procurement policies and procedures, 10. Poor sustainability practices of supplier and vendors, 11. Inadequate administration of procurement contracts, 12. Delays in obtaining procurement approvals from authorities, 13.Existence of fraud and corruption
Financial Resources	Project	FI-3	Project Financing Capabilities	1. Availability of funding source and guarantees from lenders or creditors, 2. Availability of long-term financing sources, 3. Availability of short-term finance sources	1. Lack of short-term financing sources, 2. Lack of long-term financing sources, 3. Delays in payments to lenders and creditors, 4. Poor management of outstanding debt, 5. Lack of contingency funds for unexpected situations, 6. Lack of appropriate financial plans, 7. Lack of financial risk identification and mitigation strategies, 8. Unavailability of funding source from lenders or creditors, 9. Lack of a contract between client and contractor, 10. Lack of a short-term finance
Financial Resources	Project	FI-4	Project Financial Statements	1. Accuracy and quality financial plans/forecasts, 2. Level of liquidity, 3. Project cash statement (Cash- Cash flow, net operating income), 4. Project administrative and operating budget	1. Errors in continual updates and reporting, 2. Poor monitoring and management of budget, 3. Lack of long-term assets, 4. Lack of a short-term finance/ cash, 5. Lack of funding sources (i.e. host government, lenders, creditors), 6. Lack of financial guarantees from project sponsor, 7. Lack of contingency funds for unexpected situations

Financial Resources	Corporate	FI-2	Corporate Financial Statements	1. Accuracy and quality financial plans/forecasts, 2. Accuracy of dividend payments, 3. Balance sheet strength (Capital, assets, equity), 4. BU Cash statement (Cash- Cash flow, net operating income), 5. Sources of income (shareholders, bankers etc.), 6. BU administrative and operating budget	1. Inaccurate cash model, 2. Inaccurate financial plans/forecasts, 2. Poor planning of dividend payments, 3. Delays/errors in completion of IFRS reporting, 4. Poor quality of financial data (errors, inaccuracies, etc.), 5. Poor performance in balance sheet statements, 6. Poor performance in income statements, 7. Poor asset management, 8. Lack of specialized financial risk management system
Financial Resources	Project	FI-3	Project Financing Capabilities	1. Availability of funding source and guarantees from lenders or creditors, 2. Availability of long-term financing sources, 3. Availability of short-term finance sources	1. Lack of short-term financing sources, 2. Lack of long-term financing sources, 3. Delays in payments to lenders and creditors, 4. Poor management of outstanding debt, 5. Lack of contingency funds for unexpected situations, 6. Lack of appropriate financial plans, 7. Lack of financial risk identification and mitigation strategies, 8. Unavailability of funding source from lenders or creditors, 9. Lack of a contract between client and contractor, 10. Lack of a short-term finance
Financial Resources	Project	FI-4	Project Financial Statements	1. Accuracy and quality financial plans/forecasts, 2. Level of liquidity, 3. Project cash statement (Cash- Cash flow, net operating income), 4. Project administrative and operating budget	1. Errors in continual updates and reporting, 2. Poor monitoring and management of budget, 3. Lack of long-term assets, 4. Lack of a short-term finance/ cash, 5. Lack of funding sources (i.e. host government, lenders, creditors), 6. Lack of financial guarantees from project sponsor, 7. Lack of contingency funds for unexpected situations

APPENDIX 3: FINDINGS OF SCENARIO ANALYSIS PROCESS

Table 67: Initial Scenario Assessment Log- with Textural Statements

Initial Scenario Assessment Log						
Scenario ID	**Pre-Workshop**				**During Workshop**	
	Scenario Drivers (PESTEL)				**Group Decision on Reliability**	**Textural Statements of Experts**
	Political & Economic & Legal	**Social & Environment**	**Technological**	**Business**		
S1	Opportunity	Opportunity	Opportunity	Opportunity	Yes	
S2	Opportunity	Opportunity	Opportunity	Threat	Yes	“Construction industry is project-base and it constitutes diverse stakeholders, so doing business is more volatile while compared with other industries. Thus; even the external environment provides opportunity for the industry, its inherent characteristics may still be threat”
S3	Opportunity	Opportunity	Threat	Opportunity	No	“In case political, economic, legal, social and environmental conditions are positive, it is probable that business conditions will also highly be positive. However, business environment having threats is also possible due to technological underperformance.”
S4	Opportunity	Opportunity	Threat	Threat	Yes	“If investment in technology is poor, then it is probable that business environment is more likely associated with threats”
S5	Opportunity	Threat	Opportunity	Opportunity	Yes	“If politicak, economic, legal and technological conditions are positive, then business environment can also be positive, despite the threats in social and environmental conditions.”
S6	Opportunity	Threat	Opportunity	Threat	No	“In case; political, economic and technological conditions are full of opportunities, business environment might likely have opportunities, even though possibility of having threats.”

S7	Opportunity	Threat	Threat	Opportunity	Yes	“Even if political, economic and legal conditions are positive, governments or companies may not still prefer to invest in technology or environment”. “Despite the underperformance in technological advancements, business environment can still have opportunities depending on healthy economic and political conditions.”
S8	Opportunity	Threat	Threat	Threat	No	“It is highly probable that positive conditions in political, economic and legal environment will positively affect other areas such as investment in technology, investment in new business lines and construction.”
S9	Threat	Opportunity	Opportunity	Opportunity	No	“In case the political, legal and economic environment is volatile, it is not likely to have opportunities in social, environment, technological and business environment.”
S10	Threat	Opportunity	Opportunity	Threat	Yes	“It is possible to have opportunities in social, environment and technological conditions even if there are threats in political, economic and legal conditions.” “Business environment will concurrently in threat depending on the global conditions, especially economy.”
S11	Threat	Opportunity	Threat	Opportunity	No	“It is not likely to have opportunities in business environment, if political, economic and legal conditions are volatile and are in threat.”
S12	Threat	Opportunity	Threat	Threat	Yes	“Although there may be opportunities in social and environmental conditions, political, economic and legal conditions can be a threat, which in turn triggers threats in technological and business environment.”
S13	Threat	Threat	Opportunity	Opportunity	No	“In case the political, economic, legal, social and environmental conditions are threat, then it is not possible to have opportunities in technological and business environment. Especially, business environment is largely depends on economic and political conditions”
S14	Threat	Threat	Opportunity	Threat	No	“In case the economic conditions are risky, it may not be possible to invest in technology. Thus; while the political/ economic/legal conditions are threat, it may not be possible to have opportunities in technological conditions”
S15	Threat	Threat	Threat	Opportunity	No	“While the external environment is full of threat, it is not possible to have an industry with opportunities.”
S16	Threat	Threat	Threat	Threat	Yes	“Totally everything may be in volatile, uncertain and vulnerable conditions in the future, it is possible.”

Table 68: Secondary Scenario Assessment Log

Secondary Scenario Assessment Log									
	Pre-Workshop				**During Workshop**				
	Scenario Drivers (PESTEL)				**Group Assessment**				
Scenario	**Political & Economic & Legal**	**Social & Environment**	**Technological**	**Business**	**Reliability**	**Probability of Occurrence**	**Undesirable Impact**	**Rating**	**Class**
Scenario 1	Opportunity	Opportunity	Opportunity	Opportunity	Yes	1	1	1	C
Scenario 2	Opportunity	Opportunity	Opportunity	Threat	Yes	2	3	6	C
Scenario 4	Opportunity	Opportunity	Threat	Threat	Yes	2	4	8	B
Scenario 5	Opportunity	Threat	Opportunity	Opportunity	Yes	3	2	6	C
Scenario 7	Opportunity	Threat	Threat	Opportunity	Yes	3	3	9	B
Scenario 10	Threat	Opportunity	Opportunity	Threat	Yes	3	4	12	B
Scenario 12	Threat	Opportunity	Threat	Threat	Yes	4	5	20	A
Scenario 16	Threat	Threat	Threat	Threat	Yes	5	5	25	A

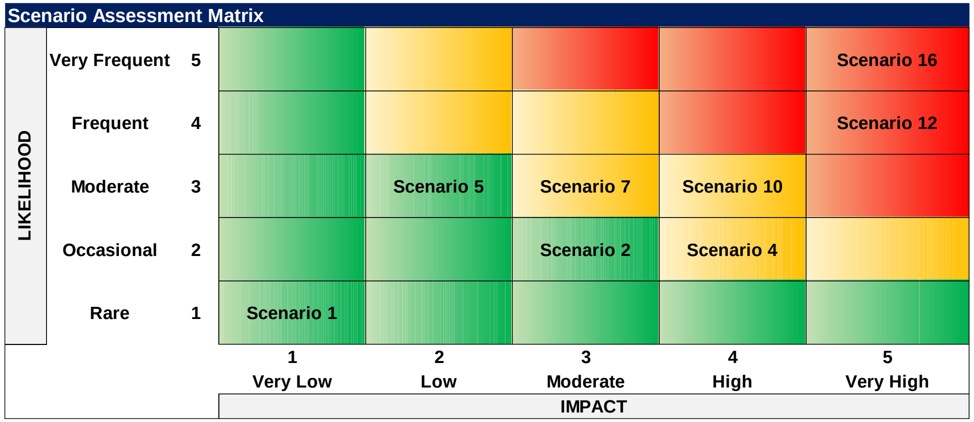


Figure 27: Scenario Assessment Matrix

Table 69: Final Scenario Assessment Log

Final Scenario Assessment Log									
	Pre-Workshop				During Workshop				
	Scenario Drivers (PESTEL)				Group Assessment				
Scenario	**Political & Economic & Legal**	**Social & Environment**	**Technological**	**Business**	**Reliability**	**Probability of Occurrence**	**Undesirable Impact**	**Rating**	**Class**
Scenario 1	Opportunity	Opportunity	Opportunity	Opportunity	Yes	1	1	1	C
Scenario 7	Opportunity	Threat	Threat	Opportunity	Yes	3	3	9	B
Scenario 16	Threat	Threat	Threat	Threat	Yes	5	5	25	A

APPENDIX 4: KEY STRATEGIC OBJECTIVES IN CONSTRUCTION FUTURE

Table 70: Key Strategic Objectives in Construction Future

Publication Information	Strategic Objectives
Publication ID: 1 **Publication Name:** Strategy for sustainable competitiveness of the construction sector and its enterprises **Leading Country/ Commission:** EU **Organization:** European Commission	1. Stimulating favorable investment conditions 2. Improving the human-capital basis of the construction 3. Improving resource efficiency, environmental performance and business opportunities 4. Strengthening the internal market for construction 5. Fostering the global competitive position of EU construction enterprises
Publication ID: 2 **Publication Name** Europe 2020- A Strategy for smart, sustainable and inclusive growth **Leading Country/ Commission:** EU **Organization:** European Commission	1. Developing knowledge and innovation 2. Strengthen the innovation chain 3. Enhance education, training and lifelong learning 4. Enhance digital society 5. Improve the business environment 6. Increasing the use of renewable sources 7. Promoting energy and resource efficiency 8. Promoting more competitive economy 9. Fostering a high-employment economy 10. Increase labor participation 11. Ensuring social and territorial cohesion 12. Developing skills throughout the lifecycle 13. Increasing competitiveness 14. Coping with climate change, clean and efficient energy
Publication ID: 3 **Publication Name** A vision for a sustainable and competitive construction sector by 2030 **Leading Country/ Commission:** EU **Organization:** European Commission	1. Industrializing the construction process 2. Facilitating a culture of co-operation and trust 3. Implementing knowledge base 4. Developing methods for achieving attractive and healthy indoor environments 5. Improving the communication and design of technologies and systems 6. Facilitating speedy and cost-effective processes 7. Reducing vulnerability, life cycle costs and disruptions 8. Enabling equal opportunities in society 9. Reducing the negative environmental impacts of construction 10. Reducing greenhouse gas emissions 11. Reducing quantities of materials and energy-use 12. Improving reparability and recycling 13. Implementing zero-waste construction activities
Publication ID: 4 **Publication Name** Strategic Research Agenda for the European Construction Sector **Leading Country/ Commission:** EU	1. Creating a built environment that is accessible and usable 2. Providing decent, well-designed, energy efficient housing 3. Providing new safe and healthy construction processes and materials 4. Using Knowledge Management tools 5. Developing automatic tools for the assessment of construction stages 6. Analyzing customer requirements

Organization: European Commission- European Construction Technology Platform	7. Making financial analysis of investment, costs and revenues 8. Assessing overall life-cycle costs of the construction 9. Developing strategic business relationships 10. Industrializing the construction process 11. Implementing intelligent equipment and materials for construction based on mechanization, automation or robotisation 12. Developing advanced ICT systems and automation 13. Developing new manufacturing systems and automation 14. Carrying out Life-cycle analysis of products 15. Developing materials with smart and sensing capabilities 16. Developing virtual design or virtual construction programs 17. Transforming into client-driven, Knowledge-based Construction Process 18. Providing Attractive Workplaces 19. Utilizing high Added-value Construction Materials 20. Reducing Resource Consumption (energy, water, materials) 21. Reduce Environmental and Man-Made Impacts 22. Adapting to climate change 23. Preserving the natural environment and resources 24. Preserving our cultural heritage
Publication ID: 7 **Publication Name** Government Construction Strategy: 2016-20 **Leading Country/ Commission:** UK **Organization:** Infrastructure and Projects Authority	1. Enhancing Client capability 2. Enhancing Digital and data capability 3. Improving skills and the supply chain 4. Incorporating whole-life approaches
Publication ID: 8 **Publication Name:** Construction 2025- Industrial Strategy: Government and Industry in Partnership **Leading Country/ Commission:** UK **Organization:** HM Government	1. Engaging young people and society at large 2. Promoting Safety and Occupational Health 3. Reinvigorating the image of the industry 4. Increasing capability in the workforce 5. Reviewing of approaches to career planning, training and development 6. Investing in smart construction and digital design 7. Bring forward more research and innovation 8. Promoting green construction 9. Promoting smart construction and digital desig 10. Making the most of BIM and offsite 11. Improve visibility and access to innovation and R&D incentives 12. Improve client capability and procurement 13. Build a low-carbon construction industry 14. Understand future work opportunities 15. Identify global trade opportunities 16. Prepare for global population growth and urbanization 17. Developing partnerships 18. Creating a strong and resilient supply chain 19. Improved trade performance
Publication ID: 9 **Publication Name:** Government Construction Strategy: 2011 **Leading Country/ Commission:** UK **Organization:** Cabinet Office- UK	1. Improving approaches to construction procurement 2. Establishing appropriate governance structures 3. Eliminating waste and duplication 4. Aligning of design/ construction with operation and asset management 5. Using building information modelling 6. Measuring supplier performance 7. Enhance competitiveness 8. Investigating new Procurement Models

	9. Developing Client Relationship Management 10. Improving co-ordination and leadership 11. Improving Governance and client skills 12. Improving Efficiency and elimination of waste 13. Improving supplier relationship management 14. Improving value for money, standards and cost benchmarking 15. Using Building information modelling 16. Increasing sustainability
Publication ID: 10 **Publication Name:** Modernizing Construction **Leading Country/ Commission:** UK **Organization:** National Audit Office (NAO)	1. Better integration of all stages in the construction process to remove waste and inefficiency 2. Focusing on whole life-cycle approaches 3. More collaboration and partnering among construction parties 4. Longer term relationships with parties to promote continuous improvements in time, cost and quality 5. Better health and safety record 6. Develop a learning culture on projects and within organisations 7. Better management of construction supply chains 8. Greater use of prefabrication and standardised building components
Publication ID: 11 **Publication Name:** Accelerating the Change **Leading Country/ Commission:** UK **Organization:** Strategic Forum for Construction	1. Accelerating Client Leadership 2. Accelerating Supply Side Integration 3. Accelerating Culture Change in 'People Issues'
Publication ID: 12 **Publication Name:** Rethinking construction **Leading Country/ Commission:** UK **Organization:** Construction Task Force	1. Develop long term relationships based on continuous improvement with a supply chain 2. Focusing on end users 3. Eliminating waste 4. Focusing on the customer 5. Promoting a quality driven agenda 6. Promoting commitment to people
Publication ID: 15 **Publication Name:** Construction 2020- A Strategy for a renewed construction sector **Leading Country/ Commission:** Ireland **Organization:** Stationary Office	1. A strategic approach to the provision of housing 2. Continuing improvement of the planning process 3. Supporting energy efficiency and sustainability 4. Availability of financing for viable and worthwhile projects 5. Strengthening public confidence and worker safety through robust regulation 6. Supporting highly skilled workforce achieving high quality and standards 7. Helping to Create Jobs and Reduce Unemployment 8. Supporting international expansion and technology advancements 9. Supporting collaboration, research and innovation 10. Competitiveness, Innovation and Internationalization
Publication ID: 16 **Publication Name:** Building our future together **Leading Country/ Commission:** Ireland **Organization:** Construction Industry Council	1. Identifying a lead body to deliver a clear and consistent vision for the construction industry 2. Addressing the public infrastructure deficit 3. Accessing funding for capital projects 4. Creating sustainable employment in the construction sector 5. Identifying export opportunities for the construction sector
Publication ID: 17 **Publication Name:**	1. Implementation of best in class procurement and planning systems

A Strategy for the Construction Industry: Construct 21 **Leading Country/ Commission:** Ireland **Organization:** Master Builders and Contractors Association	2. Reduction of costs through procurement innovation and efficiency in delivery 3. Further enhancements in quality and safety in building design and construction 4. Promotion of energy efficient, low carbon construction processes 5. A regulatory environment that promotes quality and safety in building design and construction by the most cost effective means
Publication ID: 19 **Publication Name:** Building for the future- The Scottish Construction Industry's Strategy **Leading Country/ Commission:** Scotland **Organization:** Construction Scotland	1. Developing a safer, successful and forward looking construction industry 2. Enhancing Procurement Processes and Regulation making available of attractive career paths 3. Improving track record in health and safety 4. Ensuring qualifications and training 5. Developing world-class leadership and management capability 6. Developing international trade capabilities 7. Developing and winning new orders in international markets 8. Developing new export markets, focusing on sustainable construction processes and products 9. Supporting innovation within the supply chain 10. Learning from best practice examples 11. Increasing efficiency and productivity with off-site construction 12. Focusing on waste minimization and recycling 13. Developing new materials, technologies and processes 14. Focusing on project management processes and systems 15. Focusing on "Lean" or "just in time" construction methodologies 16. Focusing on research and development, benchmarking 17. Focusing on sustainable building technologies and intelligent systems 18. Focusing on low carbon activities including zero carbon homes, retrofit, and offsite construction 19. Engaging in key policy and legislative developments
Publication ID: 20 **Publication Name:** Sustainable Competitiveness of the Construction Sector **Leading Country/ Commission:** Netherlands **Organization:** ECORYS-Research and Consulting	1. Strengthening the single market for construction through more effective regulation 2. Improving the skills base and work organizations practices through professionalization and partnerships between private and public sector 3. Improving innovation capacity and performance in all its forms in the sector with a view to increase productivity, sustainability and value added in all parts of the value chain 4. Higher sustainability in design, products, processes and operations 5. Strengthening the global competitive position of the sector
Publication ID: 21 **Publication Name:** Future Qualification and Skills needs in the construction sector **Leading Country/ Commission:** Denmark **Organization:** Danish Technological Institute	1. Attract and retain a qualified workforce 2. Improve the image of the sector among potential workers and especially young people 3. Improve health and safety conditions 4. Improve permeability between vocational education and higher education and between continuing training and further education 5. Improve job mobility and common working conditions 6. Strengthen human resource management skills 7. Enhance human capital in construction sector 8. Increase investment in continuing training 9. Improve skills and future proof skills strategies 10. Promote Sustainable construction processes 11. Use of enhanced public procurement standards and building certificates

	12. Make sustainable refurbishment/renovation a business opportunity 13. Adoption of new technologies and materials. 14. Develop innovation skills in the sector 15. Improve ICT skills
Publication ID: 23 **Publication Name:** Sectoral Innovation Foresight Construction **Leading Country/ Commission:** Australia **Organization:** Europe Innova	1. Developing new products, processes, technological trajectories 2. Promoting Eco-efficient buildings 3. Promoting smart home technologies 4. Promoting User driven design 5. Utilizing Pre-assembling 6. Utilizing Integrated design delivery 7. Utilizing Lean construction
Publication ID: 24 **Publication Name:** Construction 2020-A vision for Australia's Property and Construction Industry **Leading Country/ Commission:** Australia **Organization:** Cooperative Research Centre (CRC) for Construction Innovation	1. Promoting environmentally sustainable development correctly benchmarked and evaluated 2. Facilitating life cycle management and appraisal 3. Promoting fair procurement methods 4. Improving ICTs for more efficient working and performance 5. Improving supply-chain management and rationalization to improve efficiency of procurement and performance 6. Facilitating off-site manufacture of components to improve quality and reduce construction time 7. Improving site working conditions 8. Improving talent pool and improved skill levels 9. Improving financial and business environment for property investment and operation 10. Improving international competitiveness 11. Promoting more systematic realization of client needs and demands 12. Promoting applied R&D with seamless collaborative industry and research involvement 13. Improving attractiveness of the industry 14. Providing excellent opportunities for career development, remuneration 15. Improving health and safety 16. Offering new and innovative solutions that meet the sustainability requirements

Table 71: Key Strategic Themes in Construction Future

ST	Group 1: EU	Group 2: United Kingdom	Group 3: EU Countries	Group 4: Australia
Human & Social Capital	1. Human-Capital 2. Education, Training and Lifelong Learning, 3. High-Employment Economy, 4. Labor Participation, 5. Skill Development, 6. Equal Opportunities in Society	1. Skill Development, 2. Engaging Young People, 3. Workforce Capability, 4. Career Planning, Training and Development, 5. Future Work Opportunities, 6. Commitment to People	1. Highly Skilled and Qualified Workforce, 2. Vocational Education And Higher Education, 3. Job Mobility And Common Working Conditions, 4. Human Resource Management Skills, 5. Skills And Future Proof Skills Strategies, 6. Attractive Career Paths, 7. World-Class Leadership And Management, 8. Job Creation, Reducing Unemployment, 9. Sustainable Employment	1. Talent Pool, 2. Improved Skill Levels, 3. Opportunities For Career Development and Remuneration
Innovation and Technology Capital	1. Knowledge and Innovation, 2. Digital Society, 3. Design of Technologies and Systems, 4. Knowledge Management Tools, 5. Mechanization, Automation, Robotisation, 6. Advanced ICT Systems, 7. New Manufacturing Systems and Automation, 8. Materials with Smart and Sensing Capabilities, 9. Virtual Design, Virtual Construction Programs	1. Digital and Data Capability, 2. Smart Construction and Digital Design Research and Innovation, 3. Building Information Modelling, 4. Access to Innovation and R&D Incentives, 5. New Procurement Models, 6. Learning Culture on Projects, 7. Prefabrication and Standardized Building Components	1. Technology Advancements, 2. Research and Innovation	1. New Products, Processes,, 2. Technological Trajectories, 3. Smart Home Technologies, 4. ICTs for More Efficient Working, 5. Research & Development, 6. Innovative Solutions for Sustainability

Sustainability	1. Resource Efficiency, 2. Environmental Performance, 3. Renewable Sources, 4. Energy and Resource Efficiency, 5. Attractive and Healthy İndoor Environments, 6. Greenhouse Gas Emissions, 7. Reparability and Recycling, 8. Zero-Waste Construction Activities, 9. Accessible and Usable Built Environment, 10. Energy Efficient Housing, 11. Safe and Healthy Construction Processes and Materials	1. Safety and Occupational Health, 2. Green Construction 3. Low-Carbon Construction İndustry, 4. Efficiency and Elimination Of Waste, 5. Eliminating Waste	1. Sustainable Refurbishment/Renovation, 2. Energy Efficiency and Sustainability, 3. Worker Safety Through Robust Regulation, 4. Low Carbon Construction Processes, 5. Regulatory Environment That Promotes Quality and Safety, 6. Safer, Successful and Forward Looking, 7. Track Record in Health and Safety, 8. Sustainable Construction Processes and Products, 9. Efficiency and Productivity with Off-Site Construction, 10. Waste Minimization and Recycling, 11. Low Carbon Activities including Zero Carbon, 12. Homes, Retrofit, and Offsite Construction	1. Eco-Efficient Buildings Environmentally, 2. Sustainable Development, 3. Site Working Conditions, 4. Health and Safety
Business Opportunities & Competitiveness	1. Favorable Investment Conditions, 2. Business Opportunities, 3. Global Competitive Position, 4. Competitive Economy, 5. Financial Analysis of Investment, 6. Costs and Revenues, 7. Strategic Business Relationships, 8. Industrializing the Construction Process, 9. Culture of Co-Operation and Trust, 10. Customer Requirements	1. Image of the Industry, 2. Global Trade Opportunities, 3. Partnerships, 4. Competitiveness, 5. Collaboration and Partnering, 6. Client Capability, 7. Client Leadership, 8. Long Term Relationships, 9. Customer Focus, 10. Client Relationship Management, 11. Co-Ordination and Leadership, 12. Longer Term Relationship	1. Professionalization and Partnerships, 2. Global Competitive Position, 3. Financing for Viable and Worthwhile Projects, 4. İnternational Expansion, 5. Competitiveness, 6. Funding for Capital Projects, 7. Export Opportunities, 8. İnternational Trade Capabilities, 9. New Orders in İnternational Markets, 10. New Export Markets, 11.Key Policy and Legislative Developments	1. Financial and Business Environment, 2. İnternational Competitiveness, 3. Economic Performance, 4. Client Needs and Demands

Operational & Regulatory Excellence	1. Speedy and Cost-Effective Processes, 2. Life-Cycle Costs of the Construction	1. Whole Life-Cycle Approaches, 2. Continuous Improvements in Time, Cost and Quality, 3. Quality Driven Agenda, 4. Focusing on End Users, 5. Continuous Improvement with a Supply Chain, 6. Strong and Resilient Supply Chain, 7. Governance Structures, 8. Supplier Relationship Management, 9. Management of Construction Supply Chains	1. Value Chain, 2.Effective Regulation, 3. Public Procurement Standards and Building Certificates, 4. High Quality and Standards, 5. Best in Class Procurement and Planning Systems, 6. Procurement Innovation and Efficiency in Delivery, 7. Procurement Processes and Regulation, 8. Project Management Processes and Systems, 9. “Lean” or “Just İn Time” Construction Methodologies	1. User Driven Design, 2. Pre-Assembling, 3. Integrated Design Delivery, 4. Lean Construction, 5. Life Cycle Management and Appraisal, 6. Fair Procurement Methods, 7. Off-Site Manufacture, 8. Supply-Chain Management

Table 72: Strategic Themes and Sub-Themes

Strategic Theme	Strategic Sub-Theme	Strategy
1. Human & Social Capital	**1. Employment of New Talents & Skilled Human Capital**	**1.** Enhance human capital in construction sector
		2. Providing attractive career development, remuneration
		3. Understanding future work opportunities
		4. Developing skills throughout the lifecycle
		5. Enhance education, training, development and lifelong learning
		6. Improving talent pool and improve skills
		7. Supporting highly skilled workforce
		8. Promoting professionalisation and partnerships
		9. Strengthen human resource (HR) management skills
		10. Increasing capability in the workforce
		11. Attract and retain a qualified workforce

	2. Diversity, Employment Opportunities and Human Rights	**12.** Engaging young people and society at large
		13. Improving attractiveness and the image of the industry
		14. Increase labour participation
		15. Ensuring social and territorial cohesion
		16. Creating jobs, reducing unemployment and creating sustainable employment
		17. Promoting commitment to people
		18. Enabling equal opportunities in society
		19. Fostering a high-employment economy
2. Innovation and Technology Capital	**3. Information Capital & Digital Transformation**	**20.** Developing and using advanced ICT systems
		21. Using building information modelling
		22. Developing virtual design or virtual construction programs
		23. Investing and promoting smart construction and digital design
		24. Enhancing Digital and data capability
		25. Improving the communication and design of technologies and systems
		26. Implementing intelligent equipment and materials (mechanisation, automation, robotisation)
		27. Developing materials with smart and sensing capabilities
		28. Developing new manufacturing systems and automation
	4. Research& Development, Innovation and Organizational Learning	**29.** Improving innovation capacity and performance
		30. Improving research and development (R&D) capacity and performance
		31. Improve visibility and access to innovation and R&D incentives
		32. Supporting technology advancements
		33. Developing innovation skills in the sector
		34. Developing and adopting new materials, technologies and processes
		35. Focusing on benchmarking and learning from best practice examples

		36. Implementing knowledge base
		37. Using knowledge management tools
		38. Develop a learning culture on projects and within organisations
3. Sustainabilty	**5. Energy and Resource Consumption**	**39.** Promoting Eco-efficient buildings
		40. Higher sustainability in design, products, processes and operations
		41. Offering innovative solutions that meet the sustainability requirements
		42. Creating a built environment that is accessible and usable
		43. Increasing the use of renewable sources
		44. Promoting energy and resource efficiency
		45. Reducing quantities of materials and energy-use
		46. Focusing on sustainable building technologies and intelligent systems
		47. Focusing on low carbon construction processes and products
	6. Environmental Performance	**48.** Improving environmental performance
		49. Promoting environmentally sustainable development
		50. Promoting green construction
		51. Reducing greenhouse gas emissions
		52. Promoting smart home technologies
		53. Focusing on waste minimisation and recycling
		54. Implementing zero-waste construction activities
	7. Health and Safety Performance	**55.** Improving occupational health and safety with innovative products and processes
		56. Providing new safe and healthy construction processes and materials
		57. Creating a regulatory environment that promotes occupational health and safety
		58. Improving track record in occupational health and safety
		59. Strengthening worker safety through robust regulation

		60. Developing methods for achieving attractive and healthy indoor environments
4. Business Opportunities & Competitiveness	**8. Internalization & Competitiveness & Business Opportunities**	**61.** Improving international competitiveness
		62. Developing and winning new orders in international markets
		63. Supporing international expansion / intenationalisation
		64. Strengthening the global competitive position
		65. Stimulating favourable investment conditions
		66. Improving business opportunities
		67. Enhance competitiveness
		68. Improve the business environment
		69. Developing strategic business relationships & partnerships
	9. Customer Satisfaction & Loyalty	**70.** Promoting more systematic realizaiton of client needs and demands
		71. Developing Client Relationship Management
		72. Focusing on the client, analyzing client requirements
		73. Enhancing Client capability
		74. Facilitating a culture of co-operation and trust
	10. Financial Strength & Access to Finance	**75.** Availability of financing/funding for viable, worthwhile and capital projects
		76. Improving financial and business environment for property investment and operation
		77. Delivering outstanding economic performance
		78. Promoting more competitive economy
		79. Making financial analysis of investment, costs and revenues
5. Operational & Regulatory Excellence	**11. Design, Construction and**	**80.** Aligning of design/ construction with operation and asset management
		81. Promoting user driven design, focusing on end users
		82. Greater use of pre-assembling, prefabrication and standardised building components

	Project Delivery Methods	**83.** Utilizing integrated design delivery
		84. Focusing on “Lean” and “just in time” construction methodologies
		85. Facilitating life cycle management and appraisal, focusing on whole life-cycle approaches
		86. Increasing efficiency and productivity with off-site manufacture and construction
		87. Better integration of construction phases to remove waste and inefficiency
		88. Improving value added in all parts of the value chain
	12. Supply Chain & Trade	**89.** Developing global trade opportunities and new export market
		90. Measuring supplier performance
		91. Creating a strong and resilient supply chain, improving supply-chain management
		92. Investigating new procurement methods, reducing costs through procurement innovation
		93. Develop long term relationships with participants in supply chain
		94. Promoting fair procurement methods
		95. Implementing of best in class procurement and planning systems
		96. Improving site working conditions
	13. Regulatory Excellence	**97.** Establishing appropriate governance structures
		98. Engaging in key policy and legislative developments
		99. Developing more effective regulations
		100. Enhancing procurement processes and regulation
	14. Operational Excellence	**101.** Facilitating speedy and cost-effective processes
		102. Reducing vulnerability, life cycle costs and disruptions
		103. Assessing overall life-cycle costs of the construction
		104. Longer term relationships with parties to improve time, cost and quality
		105. Achieving high quality and standards
		106. Promoting a quality driven agenda

		107. Developing world-class leadership and management capability
		108. More collaboration and partnering among construction parties
		109. Focusing on project management processes and systems

APPENDIX 5: KPI FRAMEWORK

Table 73: KPI Framework/ Financial Perspective

ID	Measure (KPIs)	Unit	Type	Method	Polarity	Formula	Rating
	SO 1: Maximize Shareholder Value						
1	Debt to Worth Ratio	Ratio	Lagging	Quan	BoT	Debt to Worth Ratio = Creditors capital / owners capital.	3,25
2	Dividend yield	%	Lagging	Quan	Max	Dividend yield= (Dividend per share/ Price per share) × 100%	3,25
3	Earnings per share	$	Lagging	Quan	Max	Earnings per share (EPS)= (Net Income- Dividend on Preferred Stock)/ (Outstanding Shares)	3,25
4	Earnings yield	%	Lagging	Quan	Max	Earnings yield= (EPS/Share price) × 100%	2,75
5	Equity ratio	%	Lagging	Quan	Max	Shareholder Equity ratio= Shareholders' equity/ total assets.	3,75
6	Long- term value	Ratio	Lagging	Quan	BoT	Long- term value (Tobin's q)= Total Market Value of Firm/ Total Asset Value	3,25
7	Market Value Added	$	Lagging	Quan	Max	Market Value Added (MVA)= Market value of the firm (Debt and Equity) - the amount of Capital invested	3,25
8	Price-Earnings Ratio	Ratio	Lagging	Quan	BoT	Price-Earnings Ratio (P/E)= (Market Value Per Share) / (Earnings Per Share)	2,5
9	Return on Equity	%	Lagging	Quan	Max	Return on Equity (ROE) = (Net profit − preferred stock dividend) / (shareholder equity) × 100%	3,25
10	Total Shareholder Return	$	Lagging	Quan	Max	Total Shareholder Return (TSR)= Capital Gain + Dividends	3,25
SO 2: Maximize Profitability							
11	Operational Expenses	$	Leading	Quan	Min	Cost of goods sold (COGS)	4,5
12	Economic Value Added	$	Lagging	Quan	Max	Economic Value Added (EVA)= Net Operating Profit After Tax- opportunity cost of invested Capital	2,25
13	Gross Profit Margin	%	Lagging	Quan	Max	Gross Profit Margin= Gross Profit / Net Revenue; Gross Profit= Revenue - Cost of Goods Sold	4
14	Human Capital Value Added	$	Leading	Quan	Max	Human Capital Value Added (HCVA): (Revenue – Non-Employee-Related Costs) / (Number of Full-Time Employees)	1,5
15	Portfolio Profitability	$	Lagging	Quan	Max	Portfolio Profitability= Total Revenue - Total Expenses	4

16	Net Profit Margin	%	Lagging	Quan	Max	Net Profit Margin= Net Income / Net Revenue; Net Income (Net Profit) = Total Revenue- Total Expenses	4
17	Operating Profit Margin	%	Lagging	Quan	Max	Operating Profit Margin= (Operating Income) / Total Revenue Operating Profit = Income From Main Operation + Other Operating Profit − Period Expense	3,5
18	Pretax Profit Margin	%	Lagging	Quan	Max	Pretax Profit Margin= Pretax Profit/ Net Revenue	3
19	Return on Assets	%	Lagging	Quan	Max	Return on Assets (ROA)= Net Income / Total Assets	3,5
20	Return on Capital Employed	%	Lagging	Quan	BoT	Return on Capital Employed (ROCE)= EBIT / Capital Employed; Capital Employed= Debt Liabilities+ Shareholder's Equity	2,75
21	ROI of Research & Development	%	Lagging	Quan	Max	ROI of R&D: (Gain from Investment – Cost of Investment) / (Cost of Investment)	2
SO 3: Improve Revenue Growth							
22	Reduce Administrative Costs	%	Leading	Quan	Max	% administrative budget savings	3
23	Non-organic revenue growth	%	Lagging	Quan	BoT	% revenue from non-organic activities (i.e. MA)	3,25
24	EBIT / EBITDA	$	Lagging	Quan	Max	EBIT (Earnings before interest & taxes)= (Revenue) – (COGS) – (Operating Expenses) EBITDA (Earnings before interest, taxes, depreciation and amortisation)= (Revenue) – (Expenses Excluding Interest, Tax, Depreciation & Amortization)	3,75
25	Effective Tax Rate	%	Lagging	Quan	BoT	Effective Tax Rate= Income Tax Expense/ Pretax Income	3
26	Operating Income	$	Lagging	Quan	Max	Operating Income= Gross Income – Operating Expenses – Depreciation & Amortization	3,5
27	Revenue Growth	%	Lagging	Quan	Max	Revenue= (Price of Goods) x (Number of Goods Sold) Revenue Growth Rate= (Current Revenue – Past Revenue) / (Past Revenue)	4
SO 4: Improve Cash Flow Strength							
28	Accounts Payable Turnover	Ratio	Leading	Quan	BoT	Accounts Payable Turnover= Total Supplier Purchases / Average Accounts Payable	2,25
29	Accounts Receivable Turnover	Ratio	Leading	Quan	BoT	Accounts Receivable Turnover= Net Credit Sales / Average Accounts Receivable	2,25
30	Available Cash	$	Lagging	Quan	Max	Cash from operating activities, or investing activities, or financing activities	4
31	Cash Conversion Cycle	days	Leading	Quan	Min	Cash Conversion Cycle= DIO+ DSO- DPO; DIO: Days Inventory Outstanding, DSO: Days Sales Outstanding, DPO: Days Payable Outstanding	2,5
SO 5: Improve Invesment Return							
32	Internal Rate Of Return	Ratio	Lagging	Quan	Max	Internal Rate Of Return (IRR) is calculated by; net cashflow inflow, total initial investment costs and discount rate	2,5

33	Net present value	$	Lagging	Quan	Max	Net present value (NPV) is calculated by; net cashflow inflow, total initial investment costs and discount rate	2,75
34	Portfolio Return of Investment	Ratio	Lagging	Quan	Max	Portfolio Return of Investment (ROI))= (Gain from Investment – Cost of Investment) / (Cost of Investment)	3,5
SO 6: Improve Balance Sheet Performance							
35	Total Assets	$	Lagging	Quan	Max	Total Assets= Current Assets+ Long Term Assets Current Assets = Cash and Equivalents + Receivables + Inventories + Other Current Assets	3,5
36	Total Liabilities	$	Lagging	Quan	Min	Total Liabilities= short-term (current) + long-term liabilities Short-term liabilities = Accounts Payable + Short-Term Debt + Other Current Liabilities	3,5
37	Asset Utilization	%	Lagging	Quan	BoT	Asset Utilization= (Total Revenue) / (Total Assets)	3,5
38	Current Ratio	Ratio	Lagging	Quan	Max	Current Ratio= (Current Assets) / (Current Liabilities)	3
39	Debt-to-Equity Ratio	Ratio	Lagging	Quan	Min	Debt-to-Equity (D/E) Ratio= (Total Liabilities) / (Shareholders' Equity)	2,75
40	Quick Ratio / Acid Test	%	Lagging	Quan	Max	Quick Ratio / Acid Test= (Current assets- inventory) / current liabilities	2,5
41	Working Capital	Ratio	Lagging	Quan	Max	Working Capital = Current Assets - Current Liabilities	3,5

Table 74: KPI Framework/ Market & Business Growth Perspective

ID	Measure (KPIs)	Unit	Type	Method	Polarity	Formula	Rating
SO 7: Improve Market Share and Competitiveness							
42	Market Entry	#	Lagging	Quan	Max	Market Entry = # entered markets/ # planned markets	4,25
43	New Clients	#	Lagging	Quan	Max	New Clients = # new clients/ # planned clients	4,25
44	Project Complition Success	#	Lagging	Quan	Max	Project Complition Success = # or % of completed projects	3
45	Tendering performance	%	Lagging	Quan	Max	Tendering performance = # of projects won/ # of entered tender	4,5
46	Investment Performance	%	Lagging	Quan	Max	Investment Performance = $ of new investments/ $ planned investments	3,25
47	Market Share	%	Lagging	Quan	Max	Market Share = Revenue of the Company / Revenue of the Market	4
48	Profit per customer	$	Lagging	Quan	Max	Profit per customer = Net Profit/ # of Customer	3,5

49	Profit per project	$	Lagging	Quan	Max	Profit per project= Net Profit / # of Projects	4
SO 8: Improve Strategic Initiatives							
50	Revenue by Mergers and acquisitions	$	Lagging	Quan	Max	Revenue by M&A = Revenue from M&A / Total Revenue	4
51	Revenue by Partnerships	$	Lagging	Quan	Max	Revenue by Partnerships= Revenue from new partnetships/ Total Revenue	4
52	Revenue by Strategic alliances	$	Lagging	Quan	Max	Revenue by Strategic Alliances = Revenue from strategic alliances / Total Revenue	4
SO 9: Improve Internationalization							
53	New Countries	#	Lagging	Quan	Max	New Countries = # entered countries/ # planned countries	4,25
54	Growth rate of International Income	%	Lagging	Quan	Max	Growth rate of International Income: Revenue growth from previous year	4,5
55	International Income	%	Lagging	Quan	Max	International Income = Net International Income/ Net Income	4,5

Table 75: KPI Framework/ Stakeholder Perspective

ID	Measure (KPIs)	Unit	Type	Method	Polarity	Formula	Rating
SO 10: Improve Client Satisfaction & Loyalty							
56	Client Complaints	#	Lagging	Quan	Min	Customer Complaints: # of customer complaints	3,5
57	Client Growth Rate	%	Leading	Quan	Max	Client Growth Rate: Growth rate of new Clients	2,25
58	Client Loyalty Rate	%	Lagging	Quan	Max	Customer Loyalty Rate: % of customers continue doing business	3,75
59	Client Privacy	%	Leading	Quan	Max	Client Privacy = # of Client complaints about breaches of Client privacy and losses of Client data	2,5
60	Client Satisfaction Index	Rating	Lagging	Qual	Max	Customer Satisfaction Index: % of projects meeting customer expectations	4,25
61	Client Turnover (Retention) Rate	%	Lagging	Quan	Min	Customer Turnover (Retention) Rate : number of customers lost/ total number of customers	4
SO 11: Improve Reputation & Brand Recognition							
62	Level of marketing communications	#	Lagging	Quan	Max	# of marketing communications (i.e. advertising, promotion, and sponsorship)	3

63	Brand Value	$	Lagging	Quan	Max	-	3,25
64	Corporate Image and Reputation	Rating	Lagging	Qual	Max	Perception of corporate image & reputation, International reputation, user reputation, brand value, and positive reports	3,5
65	Corporate reputation of executives.	Rating	Lagging	Qual	Max	-	1,75
66	Social Networking Footprint	Rating	Leading	Qual	Max	-	2,5
SO 12: Improve Creditor and Financial Resource Availability							
67	Compliance to loan covenants	%	Leading	Quan	Max	% Compliance to loan covenants	4,25
68	Corporate credit rating	Rating	Leading	Qual	Max	-	3,75
69	Debt coverage ratio	%	Lagging	Quan	Max	Debt coverage ratio= Net income / debt payment	2,75
70	Expense Coverage Days	days	Lagging	Quan	Max		2,25
71	Internal financing ratio	%	Lagging	Quan	BoT	Internal financing ratio = $ of internal financing/ $ of total project financing	3,75

Table 76: KPI Framework/ Project Management Perspective

ID	Measure (KPIs)	Unit	Type	Method	Polarity	Formula	Rating
SO 13: Improve Cost Management Performance							
72	Average costs per project	$	Lagging	Quan	Min	Average costs per project= Total Cost / Number of Projects	4
73	Portfolio or Average Cost Variance	$/ %	Lagging	Quan	Min	Portfolio Cost Variance = (Actual Cost of Portolio - Budgeted Cost of Portolio) Average Cost Variance = Portfolio Cost Variance /Portfolio Size	4,5
74	Portfolio or Average NPV Variation	$/ %	Lagging	Quan	Min	Portfolio NPV Variation = Total Actual NPV - Total Planned NPV Average NPV Variation = Portfolio NPV Variation / Portfolio Size	2,5
75	Actual Cost of Work Performed	$	Lagging	Quan	Max	Actual Cost of Work Performed (ACWP): Sum of actual costs of activities that are completed.	4,25
76	Revenue per project	$	Lagging	Quan	Max	Revenue $ generated per project= Total Revenue / Number of Projects	4

77	Billing Performance Index	ratio	Leading	Quan	Max	Billing Performance Index (BPI)= BRWP/ERWP BRWP = Billed revenue of work performed; ERWP = Earned revenue of work performed	3,5
78	Budgeted Cost of Work Performed	$	Lagging	Quan	BoT	Budgeted Cost of Work Performed (BCWP)= Earned Value	4,25
79	Cost Performance Index	ratio	Lagging	Quan	Min	Cost Performance Index (CPI): Earned Value / Actual cost (BCWP/ACWP) ACWP = Actual Cost of Work Performed, BCWP= Budgeted Cost of Work Performed	4,25
80	Cost Schedule Index	ratio	Leading	Quan	Max	Cost Schedule Index (CSI): Cost Performance Index * Schedule Performance Index (CPI x SPI)	3,25
81	Estimate at Completion	$	Lagging	Quan	BoT	Estimate at Completion (EAC): Actual cost of work performed (ACWP) + the estimate to complete (ETC) for all of the remaining work.	4
82	Portfolio Break-Even Time Variation	hr	Lagging	Quan	Min	Break-Even Time Variation= Planned (baseline) time- actual break even time	2,25
83	Profitability Performance Index	ratio	Lagging	Quan	Max	Profitability Performance Index (PPI) = ERWP/ACWP ERWP = Earned revenue of work performed, ACWP = Actual cost of work performed	4,5
84	Portfolio Profitability Performance Index	ratio	Lagging	Quan	Max	Profitability Performance Index (PPI) = ERWP/ACWP ERWP = Earned revenue of work performed, ACWP = Actual cost of work performed	4,5
85	Project Break-Even Time Variation	yr	Lagging	Quan	Min	Project Break-Even Time Variation: (Actual break even time) - (Planned (baseline) time)	2,25
86	Project Cost Variance	$/ %	Lagging	Quan	Min	Project Cost Variance = (Actual Project Cost - Budgeted Project Cost)	4,5
87	Project NPV Variation	$	Lagging	Quan	Min	Project NPV Variation = Actual NPV - Planned NPV	2,5
88	Budgeted Cost of Work Scheduled (BCWS)	$	Lagging	Quan	BoT	Budgeted Cost of Work Scheduled (BCWS)= Planned Value	3,25
SO 14: Improve Time Management Performance							
89	Deviation in project construction hour	hr	Leading	Quan	Min	Deviation in project construction hour = Planned construction hours - actual construction hours	4
90	Milestone Achievement Ratio	%	Leading	Quan	Max	Milestone Achievement Ratio = milestones that have been achieved / all milestones	3,5
91	Overdue project tasks	%	Leading	Quan	Min	Overdue project tasks: % of overdue project tasks.	3,75
92	Planning Effectiveness	%	Leading	Quan	Max	Planned Completed (PPC) = Planned Activities Completed / Total Number of Planned Activities	3,5

93	Portfolio or Average Schedule Variation	hr/ %	Leading	Quan	Min	Portfolio Schedule Variation: (Actual Portfolio Duration – Planned Portfolio Duration) Average Variation: (Portfolio Schedule Variation)/ Portfolio Size	4,5
94	Project issue queue rate	ratio	Leading	Quan	Min	Project issue queue rate: # of project issues closed / # of project issues opened in a given time period.	2,5
95	Project Schedule Variation	hr	Leading	Quan	Min	Project Schedule Variation: (Actual Project Duration – Planned Project Duration)	4,5
96	Schedule Performance Index	%	Leading	Quan	Max	Schedule Performance Index (SPI)= Earned Value / planned value (BCWP/BCWS)	3,5
97	Project Schedule Variation	$	Leading	Quan	Min	Project Schedule Variance (SV)= Earned Value - Planned budget for the completed work (BCWP-BCWS)	4
98	Speed of Construction	m2/ days	Leading	Quan	Max	Speed of Construction= Gross floor area / construction time	3,5
SO 15: Improve Quality Management Performance							
99	Level of Quaility Assurance Review	%	Lagging	Quan	Max	Level of Quaility Assurance Review = % of projects receiving Quaility Assurance review	3,75
100	Change Cost Factor	%	Leading	Quan	Min	Change Cost Factor= Total Cost of Changes/ Actual Total Project Cost	2,5
101	Portfolio Change Cost Factor	%	Leading	Quan	Min	Change Cost Factor= Total Cost of Changes/ Actual Total Project Cost	2,5
102	Cost of Client Claims	%	Lagging	Quan	Min	Cost of Client Claims = Cost of Repairing Client Claims / Total Project Cost	4,25
103	Cost of defects/ rework	$	Lagging	Quan	Min	-	3,5
104	Quality performance index (QPI	$	Leading	Quan	Min	Quality performance index (QPI) & Construction field rework index (CFRI) = Rework Factor	3
105	Total Field Rework Factor	%	Leading	Quan	Min	Total Field Rework Factor: Total Direct Cost of Field Rework / Actual Construction Phase Cost	4
SO 16: Improve Project Management Skills (Scope, Integration, Communication)							
106	Scope Change/ Creep	#	Leading	Quan	Min	Scope Change/ Creep = number of scope change requested by the client or sponsor	3
107	Change order	%	Lagging	Quan	Min	Change order = $ of change orders/ budgeted cost	3,75
108	Change in Contract Amount	%	Lagging	Quan	BoT	Change in Contract Amount = Final Contract Sale / Initial Contract Sale	4
109	Scope Performance Index	ratio	Leading	Quan	Max	-	3
110	Portfolio Scope Performance Index	ratio	Leading	Quan	Max	-	3

SO 17: Improve Supply Chain Management Performance							
111	Compliance to custom and trade regulations	%	Leading	Qual	Max	Compliance to custom and trade regulations = % compliance with with taxes, customs, trade and other regulations	3,5
112	Transit Efficiency	%	Leading	Quan	Min	Transit Efficiency = % loss of or damage to goods in transit	3,75
113	Suppliers/ Subcontractors Performance Evaluation	%	Leading	Quan	Max	Suppliers/ Subcontractors Performance Evaluation = % of suppliers/ subcontractors those evaluated after purchase orders	3
114	Quality of purchased materias	%	Leading	Quan	Max	Quality of purchased materias = % quality of purchased materias	4
115	Preferred supplier/ subcontractor list	%	Leading	Quan	Max	Preferred supplier/ subcontractor list = % use of preferred supplier/ subcontractor list	2,5
116	Average Procurement Delay Time	days	Leading	Quan	Min	Average Delay Time: Average Time of Delays (Actual Delivery is after Scheduled Delivery Date)	3,75
117	Compliance with procurement procedures and specifications	%	Leading	Qual	Max	Compliance with procurement procedures and specifications = % compliance with procurement procudures and policies, specifications	3,5
118	Procurement Delivery Time	days	Leading	Quan	Min	Procurement Delivery Time: Time Elapsed between Material Order and Delivery on Site	3,25
119	Level of non conformities during vendor inspection	#	Leading	Quan	Min	Level of non-conformities during vendor inspection = # of non-conformities during inspection against a particular vendor.	3
120	Subcontractor Ratio	%	Lagging	Quan	BoT	Subcontractor Ratio= Subcontracted Costs / Total Project Cost	2,5
121	Portfolio Subcontractor Ratio	%	Lagging	Quan	BoT	Subcontractor Ratio= Subcontracted Costs / Total Project Cost	2,5
122	Level of Urgent Orders	ratio	Leading	Quan	Min	Level of Urgent Orders= Number of urgent orders/total number of orders	2
SO 18: Improve Site Management Performance							
123	Efficiency of Direct Labour	%	Lagging	Quan	Max	Efficiency of Direct Labour = Actual Cost of Manhours/ Budgeted Cost of Man-hours	4,75
124	Labor Productivity	%	Leading	Quan	Max	Efficiency of Direct Labour = Actual labor manhour/planned manhour	4,25
125	Equipment productivity	%	Lagging	Quan	Max	Equipment productivity = % stand by hours	3
126	Lost Time Accounting	mhr	Leading	Quan	Min	Lost Time Accounting = number of man-hours lost due to idle time	3,25
127	Work intensity	mhr/m2	Leading	Quan	BoT	Work intensity = man hour / m2	3,5
128	Defects entered in the handing-over protocol	#	Leading	Quan	Min	-	3,5
129	Number of Client Claims	#	Leading	Quan	Min	-	4

130	Number of defects & nonconformities	#	Leading	Quan	Min	-	4
131	Ratio of defects/ Rework	%	Leading	Quan	Min	Ratio of defects/ Rework = Rework manhour/ total manhour	3,5
132	Rejection Level: % sample rejections	%	Leading	Quan	Min	Rejection Level= % sample rejections	3,5
133	Square meter price	$/m2	Leading	Quan	Min	Square meter price= Final contract sum / gross floor area.	3,5
SO19: Improve Design and Engineering Performance							
134	Design changes	%	Leading	Quan	Min	Design changes = Number of changes/ total number of drawings	3,5
135	Design Errors	%	Leading	Quan	Min	Design Errors = Number of Design Errors / Total Number of Drawings	4,5
136	Quality of Design	Ratio	Leading	Quan	Min	Quality of Design = Number of Client Non-Conformities / Total Project Cost	4,5
137	Cost of Client Claims	$	Lagging	Quan	Min	Cost of Client Claims = Cost of Repairing Claims (Client Complaints) (Defects) / Total Project Cost	4,25

Table 77: KPI Framework/ Governance and Compliance Perspective

ID	Measure (KPIs)	Unit	Type	Method	Polarity	Formula	Rating
SO 20: Improve Contract Management Performance							
138	Average cost per lawsuit	$	Lagging	Quan	Min	Average cost per lawsuit= Total cost of lawsuits / number of lawsuits	3,75
139	Income from Claims	$	Lagging	Quan	Max	Income from Claims= # of claims/ earned premium	4,25
140	Cost of legal spending	$	Lagging	Quan	Min	Total legal spending as % of revenue= internal costs (ie. Compensation) + external costs (ie. outside counsel)	3,25
141	Saving from litigation cases	$	Lagging	Quan	Max	$ saving from litigation cases "won"/ Total costs of litigation outcome % Litigation Cases 'Won'	3,25
142	Timeliness of legal opinions	hr	Leading	Quan	Min	Average legal opinion response time	1,75
SO 21: Improve Regulatory Compliance							
143	Compliance to work requirements	%	Leading	Quan	Min	Compliance to work requirements = % errors /delays in obtaining worker accreditation and certifications	3
144	Compliance to construction licensing and permits	%	Leading	Quan	Min	Compliance to construction licensing and permits = % errors/ delays in obtaining construction licensing and permits	4

145	Compliance to Design Codes and Standards	%	Leading	Quan	Min	Compliance to Design Codes and Standards = % errors/delays in satisfying design and engineering codes and standards	3,25
146	Level of re-opened compliance issues	%	Leading	Quan	Min	Level of re-opened compliance issues= % of re-opened compliance issues	2,25
147	Backlog of compliance issues	#	Leading	Quan	Min	Backlog of compliance issues = # of open compliance issues	2,25
148	Compliance to international accounting standards	%	Leading	Quan	Max	Compliance to international accounting standards = % errors /delays in compliance to international accounting standards	4
149	Compliance to multi country government regulations	Rating	Leading	Qual	Max	-	3,5
150	Cost of compliance	$	Lagging	Quan		Cost of compliance = Total Corporate cost to comply with regulatory requirements	3
151	Cost of Payroll Penalties	$	Lagging	Quan	Min	Cost of payroll penalties = Payroll penalties/ all payroll statements	3,25
152	Cost of regulatory non-compliance	$	Lagging	Quan	Min	Cost of regulatory non-compliance = Cost of payroll penalties + Cost of tax penalties	4
153	Cost of Tax Penalties	$	Lagging	Quan	Min	Cost of tax penalties = Tax penalties/ all tax statements	3,5
154	Quality of Transactions	%	Leading	Quan	Max	% errors in transactions = Errors in transactions/ all transactions	2,25
155	Compliance to external qualification and certifications	#	Leading	Quan	Min	Compliance to external qualification and certifications = # of weaknesses identified by external qualification and certification reports.	3,25
156	Frequency of compliance reviews & audits	#/year	Leading	Quan	Max	Frequency of compliance reviews & audits = # of compliance reviews /year	3
157	Quality of Payrolls Payments	%	Leading	Quan	Max	Quality of Payrolls = 1- (# of Payment errors/ total payroll disbursement*100%)	2,5
158	Quality of periodic financial reports	%	Leading	Quan	Max	Quality of periodic financial reports = 1- (# of identified errors in financial reports)*100%	2,5
159	Quality of Tax Calculation	%	Leading	Quan	Min	% errors in tax calculation = Errors in tax statements/ all tax statements	2,5
160	Timeliness of Regulatory Compliance	%	Leading	Quan	Max	Timeliness of Regulatory Compliance = % Regulations met by required date	3
161	Regulatory or legal noncompliance issues	#	Leading	Quan	Min	Regulatory or legal noncompliance issues = # of regulatory or legal noncompliance issues identified	3
162	Timeliness of Financial Reports	%	Leading	Quan	Max	Timeliness of Financial Reports = % of financial reports issued on time	3,25
163	Timeliness of Payroll Payments	%	Leading	Quan	Min	Timeliness of Payroll Payments = Untimely payments / All payments	2,5
164	Timeliness of Tax Payments	%	Leading	Quan	Max	Timeliness of Tax Payments = Paid in time/ all payments Overdue tax statements = Overdue tax statements/ all tax statements	3

SO 22: Improve Risk Management Performance							
165	Level of Corruption and Fraud	#	Leading	Quan	Min	Level of Corruption and Fraud = # of confirmed incidents of corruption, bribery, fraud or anti-trust practices	3,5
166	Success of Risk Assessment	%	Leading	Quan	Max	Success of Risk Assessment = % of critical business services covered by risk analysis	2,75
167	Quality of Policies	%	Leading	Quan	Min	Quality of Policies = % of policies reported with non-conformances	2,5
168	Level of Corruption Review	%	Leading	Quan	Max	Level of Corruption Review= % of projects analyzed for risks related to corruption	2,75
169	Portfolio Risk Profile	%	Leading	Qual	Min	Portfolio Risk Profile = % of projects with high risk profile	4
170	Success of Risk Mitigation	%	Leading	Quan	Min	Success of Risk Mitigation = % of risk mitigation plans executed successfully	2,75
171	Reduction in Recurring Audit Findings	%	Leading	Quan	Max	Reduction in Recurring Audit Findings = % reduction in recurring audit finding instances (non-conformities etc.)	3
172	Corrective action response time	days	Leading	Quan	Min	Corrective action response time = Average of time to implement corrective action	2,5
173	Cost of Total Risk Exposure	$	Lagging	Quan	Min	Cost of total risk exposure= % of actual risk event that has occurred in certain period of time * financial impact	3,75
174	Quality of Risk Identification	%	Leading	Quan	Min	Quality of Risk Identification = % of unassessed identified risks.	2,75

Table 78: KPI Framework/ Sustainability Perspective

ID	Measure (KPIs)	Unit	Type	Method	Polarity	Formula	Rating
SO 23: Improve Environmental Performance							
175	Reduction in energy consumption	%	Leading	Quan	Max	Reduction in energy consumption= (Initial - Final)/ Initial energy consumption	4
176	Waste Reduction Rate	%	Leading	Quan	Max	Waste Reduction Rate= % of construction and demolition waste reduced or recycled	3,75
177	Compliance to environmental standards	%	Leading	Qual	Max	Compliance to environmental standards = % of compliance to environmental policies and standards	3,5
178	Budget Savings from Energy	$	Lagging	Quan	Max	Budget Savings from Energy= $ of energy saved by conservation and efficiency improvements.	3,25

179	Green Energy Consumption	%	Leading	Quan	Max	Green Energy Consumption = % consumption of green energy	3,25
180	Reduction in greenhouse gas emissions	%	Leading	Quan	Max	Reduction in greenhouse gas emissions = % reduction of greenhouse gas emissions created from operations	3,25
181	Carbon Footprint	Ratio	Leading	Quan	Min	-	3,25
182	Waste Recycling & Reuse Rate	%	Leading	Quan	Max	Waste Recycling & Reuse Rate = % of materials used that are recycled input materials	3,25
183	Level of Negative Environmental Impacts	#	Leading	Quan	Min	Level of Negative Environmental Impacts = # of significant actual and potential negative environmental impacts in the supply chain and actions taken	3
184	Supplier Environmental Performance	%	Leading	Quan	Max	Supplier Environmental Performance = % of suppliers that are screened using environmental criteria	3
185	Water Recycle and Reuse Rate	%	Leading	Quan	Max	Water Recycle and Reuse Rate= % of volume of water recycled & reused	3
186	Reduction in other air emissions	%	Leading	Quan	Max	Reduction in other air emissions = % reduction of other siginificant air emissions created from operations	2,5
187	Cost of negative environmental impacts	$	Lagging	Quan	Max	-	2,5
188	Compliance to Waste Discharge Requirements	Ratio	Leading	Qual	Max	Compliance to Waste Discharge Requirements = % of waste discharge compliance	2,5
189	Level of impacts in protected areas	#	Leading	Quan	Min	Level of impacts in protected areas = # of significant impacts of activities in protected areas/high biodiversity areas	2,25
190	Water Footprint	Ratio	Leading	Quan	Min	-	2
191	Level of habitats protected or restored	#	Leading	Quan	Max	Level of habitats protected or restored = # of habitats protected or restored	1,75
SO 24: Improve Health and Safety Performance							
192	Fatalities	#	Leading	Quan	Min	Fatalities= # of work-related fatalities	4,5
193	Accident Frequency	#	Leading	Quan	Min	Accident Frequency= Number of accidents *100 / total number of workers	4,25
194	Level of incidence and risk of diases	#	Leading	Quan	Min	Risk of Disease= # of workers with high incidence or high risk of diseases related to their occupation	3,5
195	Lost Time Incidents	ratio	Leading	Quan	Min	Lost Time Incidents (LTI) = Number of lost time incidents to date Lost Time Accidents (Total Recordable Incident Rate) = (Total Number of Recordable Cases x 200,000)/ Total Site Work-Hours C = a constant (200,000), which represents 100 employees working for a full year (100 × 2; 000); M = Total work hours expended to date;	3,5
196	Health and Safety Assessment	%	Leading	Quan	Max	Health and Safety Assessment = % of products/services assessed for health & safety impacts	3,25

SO 25: Improve Social Performance							
197	Level of negative impacts on society & local communities	#	Leading	Quan	Min	Level of negative impacts on society & local communities = # and extent of negative impacts on society & local communities	3,75
198	Level of discrimination	#	Leading	Quan	Min	Level of discrimination = # of incidents of discrimination	2,75
199	Level of negative impacts about human rights	#	Leading	Quan	Min	Level of negative impacts about human rights = # of significant actual and potential negative human rights impacts in the supply chain	2,25
200	Level of Supplier Assessment for Labor Practices/Society	#	Leading	Quan	Min	Level of Supplier Assessment for Labor Practices/Society = # of significant actual and potential negative impacts for labor practices/society in the supply chain	3,25
201	Maturity in Age Diversity	%	Leading	Quan	BoT	Maturity in Age Diversity = % age group	3
202	Maturity in Gender Diversity	%	Leading	Quan	BoT	Maturity in Gender Diversity = % gender distribution	3,5
203	Training on human rights policies or procedures	%	Leading	Quan	Max	Training on human rights policies or procedures = % of employees trained on human rights policies or procedures	2,25
204	Level of Customer Sustainability Practice	%	Leading	Quan	Max	Level of Customer Sustainability Practice = % of compliance of client to HSE law, regulation and policies	3,5
205	Level of local community engagement	%	Leading	Quan	Min	Level of local community engagement = % of operations with implemented local community engagement, impact assessments, and development programs	2,25
206	Spending on locally-based suppliers	%	Leading	Quan	BoT	Spending on locally-based suppliers = Spending on locally-based suppliers / Spending on all suppliers	2,75
207	Level of screening of suppliers and subcontractors on human rights	%	Leading	Quan	Max	Level of screening of suppliers and subcontractors on human rights = Suppliers and subcontractors screened on human rights/ Total number of suppliers	2,25
208	Involvement of workforce with disabilities	%	Leading	Quan	BoT	Involvement of workforce with disabilities = Workforce who are persons with disabilities/ Total Workforce	3,25
209	Involvement of workforce with visible minorities	%	Leading	Quan	BoT	Involvement of workforce with visible minorities = Workforce who are visible minorities/ Total Workforce	2,75
210	Existence of health and safety improvement programs	%	Leading	Qual	Max	-	3,25
211	Female-Male salary ratio	Ratio	Leading	Quan	BoT	Female-Male salary ratio= Total salary of female workers/ Total salary of male workers	2,75
212	Residual cost of negative human rights impacts	$	Lagging	Quan	Min		2
213	Involvement of local employees	%	Leading	Quan	Max	Involvement of local employees = % of local employees	2,25

214	Involvement of Woman	%	Leading	Quan	Max	Involvement of Woman = % of woman in management	3,5
215	Use of material from local resources	%	Leading	Quan	Max	Use of material from local resources = % of material from local resources	1,5
216	Involvement of certified suppliers	%	Leading	Quan	Max	Involvement of certified suppliers = % of certified suppliers	2,75

Table 79: KPI Framework/ Learning and Growth Perspective

ID	Measure (KPIs)	Unit	Type	Method	Polarity	Formula	Rating
SO26: Improve Human Capital Capability							
217	High performing employees	%	Leading	Quan	Max	High performing employees = High performing employees/ Total number of employees	4,25
218	Turnover of key personnel	%	Leading	Quan	Min	Turnover of key personnel = Key Personnel Exit / All Exists	4,25
219	Employee Motivation and Satisfaction Index	Ratio	Leading	Qual	Max	-	3,75
220	Staff Turnover	%	Leading	Quan	Min	Staff Turnover = % of staff leaves / total staff	3,75
221	Skills management and lifelong learning	#	Leading	Quan	Max	Skills management and lifelong learning # of programs for skills management and lifelong learning	3,75
222	Job offer acceptance rate	%	Leading	Quan	Max	Job offer acceptance rate = # of accepted job offers / Total number of job offers made	3,5
223	Effectiveness of benefit & social contribution	Ratio	Leading	Qual	Max	-	3,5
224	Training and Education Level	%	Leading	Quan	Max	Training and Education Level = Number of employees provided regular training opportunities/ Total number of employees	3,5
225	Performance and career development reviews	%	Leading	Quan	Max	Performance and career development reviews = Number of employees receiving regular performance and career development reviews/ Total number of employees	3,25
226	Employee Engagement Level	Ratio	Leading	Qual	Max	-	3
227	Level local employees	%	Leading	Quan	BoT	Level local employees= Number of local employees/ Total number of employees	3
228	Time to Hire	days	Leading	Quan	Min		3

229	Sickness absenteesim	%	Leading	Quan	Min	Sickness absenteesim = # of lost man-hours due to absences / the duration of the construction project	2,75
230	Retention rates after parental leave	%	Leading	Quan	Min	Retention rates after parental leave= % Return to work and retention rates after parental leave	2,5
231	360-Degree Feedback Score	Ratio	Leading	Quan	Max	-	2,25
SO 27: Improve Technology & Innovation Capability							
232	Level of Technology Continuity	ratio	Leading	Qual	Max	Level of Technology Continuity: Existence of services not covered in continuity plan, amount of business disruptions, amount of capacity unavailability time	2,5
233	Six Sigma Level	Ratio	Leading	Qual	Max	-	2
234	Information Security	Ratio	Leading	Quan	Min	Information Security: Breaches in information security and loss of confidentiality	1,75
235	Return on Innovation Investment	Ratio	Lagging	Quan	Max	Return on Innovation Investment = Gain from innovation/ Innovation Spending	2,5
236	Level of Technology Incidents	%	Leading	Quan	Min	Level of Technology Incidents= Duration of unavailable time due to incidents in IT environment/ Total Project Duration	2,75
237	Continuous Improvement Level	%	Leading	Qual	Max	Continuous Improvement Level= % of implemented continuous improvement opportunities	3
238	Technology Spending	$	Lagging	Quan	Min	Technology Spending = $ of unnecessary/unplanned IT costs	2,75
239	Innovation Spending	$	Lagging	Quan	Max	Innovation Spending : $ spent in innovation	3,25
240	Innovation Integration Level	Ratio	Leading	Qual	Max	Innovation Integration Level : Integration of novel technologies	3,5
241	Innovation Pipeline Strenght	%	Leading	Quan	Max	Innovation Pipeline Strenght : % of ideas that turned into innovation project	3,75
242	Technology Integration Level	Ratio	Leading	Qual	Max	Technology Integration Level : Advantage and integration of IT development, such as ERP, OA, CRM, HRM, SCM	3,5
SO 28: Improve Knowledge & Intellectual Capital							
243	Level of Standards Certification	$	Leading	Quan	Max	Level of Standards Certification = ISO/OHSAS or EMAS certification (as % of projects)	3
244	Project Lessons Learned Sessions	%	Leading	Quan	Max	Project Lessons Learned Sessions = % of lessons learnt sessions per registered projects before project close outs completed	4,25
245	Organizational Policy and Procudures	%	Leading	Quan	Max	Organizational Policy and Procudures = % of business processes those covered with defined and documented organizational cycles and procedures	4,25
246	Project Post-Project Review	%	Leading	Quan	Max	Project Post-Project Review = % of projects with post-project review	3,75

APPENDIX 6: MODEL PARAMETERS

Table 80: Model Parameters for Financial Perspective

Perspective	ID	Conceptual Type	Computerized Type	Parameter	Units
Financial	1	KPI	Stock	Total Project Revenue	USD
Financial	2	KPI	Flow	Yearly Project Revenue	USD/Years
Financial	3	KPI	Converter	Gross Profit Margin	Dimensionless
Financial	4	KPI	Stock	Total Gross Profit	USD
Financial	5	KPI	Flow	Yearly Gross Profit	USD/Years
Financial	6	Formulation	Stock	Other Operating Gains	USD
Financial	7	Formulation	Flow	Yearly Other Operating Gains	USD/Years
Financial	8	Formulation	Stock	Total Shareholder Revenue	USD
Financial	9	Formulation	Flow	Yearly Shareholder Revenue	USD/Years
Financial	10	KPI	Stock	Total Net Profit	USD
Financial	11	KPI	Flow	Yearly Net Profit	USD/Years
Financial	12	KPI	Converter	Net Profit Margin	Dimensionless
Financial	13	Formulation	Stock	Total Project Expenses	USD
Financial	14	Formulation	Flow	Yearly Project Expenses	USD/Years
Financial	15	Formulation	Stock	Total Company Expenses	USD
Financial	16	Formulation	Flow	Yearly Company Expenses	USD/Years
Financial	17	Formulation	Stock	Total General & Administrative Expenses	USD
Financial	18	Formulation	Flow	Yearly G&A Expenses	USD/Years
Financial	19	Formulation	Converter	Contract Markup	Dimensionless

Financial	20	Initial	Converter	Contract Profit Margin	Dimensionless
Financial	21	Formulation	Converter	Risk-Related Contingency	Dimensionless
Financial	22	Initial	Converter	Max Limit for Contract Profit Margin	Dimensionless
Financial	23	Initial	Converter	Min Limit for Contract Profit Margin	Dimensionless
Financial	24	Formulation	Flow	Total Budget of Initial Projects	USD/ Years
Financial	25	Initial	Converter	Initial Budget of National Projects	USD/ Projects
Financial	26	Initial	Converter	Initial Budget of International Projects	USD/ Projects
Financial	27	Formulation	Converter	Targeted Budget of Potential National Projects	USD/ Projects
Financial	28	Formulation	Converter	Targeted Budget of Potential International Projects	USD/ Projects
Financial	29	Formulation	Converter	Tax Expenses	USD/Years
Financial	30	Initial	Converter	VAT %	Dimensionless
Financial	31	KPI	Flow	Yearly Budget of Newly Awarded National Projects	USD/Years
Financial	32	KPI	Flow	Yearly Budget of Newly Awarded International Projects	USD/Years
Financial	33	KPI	Flow	Yearly Total Budget of Newly Awarded Projects	USD/Years

Table 81: Model Parameters for Market and Business Growth Perspective

Perspective	ID	Conceptual Type	Computerized Type	Parameter	Units
Market and Business Growth	34	Formulation	Converter	Complexity	Dimensionless
Market and Business Growth	35	KPI	Converter	Total Completed Projects	Projects
Market and Business Growth	36	KPI	Converter	Total Ongoing Projects	Projects
Market and Business Growth	37	KPI	Stock	Ongoing National Projects	Projects
Market and Business Growth	38	Formulation	Flow	National Projects Completion Rate	Projects/Years
Market and Business Growth	39	Formulation	Stock	Completed National Projects	Projects

Market and Business Growth	40	Initial	Converter	Initial Ongoing National Projects	Projects
Market and Business Growth	41	Initial	Converter	Initial Ongoing International Projects	Projects
Market and Business Growth	42	Formulation	Stock	Ongoing International Projects	Projects
Market and Business Growth	43	Formulation	Flow	International Projects Completion Rate	Projects/Years
Market and Business Growth	44	Formulation	Stock	Completed International Projects	Projects
Market and Business Growth	45	Formulation	Flow	Newly Awarded National Projects	Projects/Years
Market and Business Growth	46	Formulation	Converter	Targetted Number of National Projects	Projects/Years
Market and Business Growth	47	Initial	Converter	Manageable Max Number of National Projects	Projects/ Years
Market and Business Growth	48	Formulation	Flow	Newly Awarded International Projects	Projects/Years
Market and Business Growth	49	Formulation	Converter	Targetted Number of International Projects	Projects/Years
Market and Business Growth	50	Initial	Converter	Manageable Max Number of International Projects	Projects/ Years
Market and Business Growth	51	Formulation	Converter	Yearly Total Newly Awarded Projects	Projects/Years
Market and Business Growth	52	Formulation	Converter	Yearly Total Targeted Projects	Projects/ Years
Market and Business Growth	53	Formulation	Converter	Attractiveness of National Construction Market	Dimensionless
Market and Business Growth	54	Formulation	Converter	Attractiveness of International Construction Market	Dimensionless
Market and Business Growth	55	GM	Converter	G/M: Country Political Stability	Dimensionless
Market and Business Growth	56	GM	Converter	G/M: Country Economic Growth and Development	Dimensionless
Market and Business Growth	57	GM	Converter	G/M: National Demand	Dimensionless
Market and Business Growth	58	GM	Converter	G/M: Strength of National Competitors	Dimensionless
Market and Business Growth	59	GM	Converter	G/M: Strength of International Competitors	Dimensionless
Market and Business Growth	60	GM	Converter	G/M: Global Political Stability	Dimensionless
Market and Business Growth	61	GM	Converter	G/M: Global Economic Growth and Development	Dimensionless
Market and Business Growth	62	GM	Converter	G/M: Favorability of International Relations	Dimensionless
Market and Business Growth	63	GM	Converter	G/M: Global Demand	Dimensionless

Market and Business Growth	64	RC	Converter	R/C: Ability to Make Lowest Bid	Dimensionless
Market and Business Growth	65	Initial	Converter	Market Ave. Contract Markup	Dimensionless
Market and Business Growth	66	KPI	Converter	Tendering Performance	Dimensionless
Market and Business Growth	67	Formulation	Converter	Yearly Project Completion	Projects/Years

Table 82: Model Parameters for Stakeholder Perspective

Perspective	ID	Conceptual Type	Computerized Type	Parameter	Units
Stakeholder	68	KPI	Converter	R/C: Competitive Advantage	Dimensionless
Stakeholder	69	KPI	Stock	Client Satisfaction and Loyalty	Dimensionless
Stakeholder	70	Formulation	Flow	Yearly Imp of Client Satisfaction	1/Year
Stakeholder	71	KPI	Converter	Client Retention Rate	Dimensionless
Stakeholder	72	Formulation	Flow	Disposal of Client Satisfaction	1/Year
Stakeholder	73	GM	Converter	G/M: Level of Client Expectations	Dimensionless
Stakeholder	74	KPI	Stock	Reputation (for other stakeholders)	Dimensionless
Stakeholder	75	Formulation	Flow	Yearly Imp. of Reputation	1/Year
Stakeholder	76	Formulation	Flow	Disposal of Reputation	1/Year
Stakeholder	77	GM	Converter	G/M: Power of Media	Dimensionless
Stakeholder	78	GM	Converter	G/M: Level of Society Demands	Dimensionless
Stakeholder	79	RC	Converter	R/C: Relations with Media	Dimensionless
Stakeholder	80	KPI	Stock	Creditor and Financial Resource Availability	Dimensionless
Stakeholder	81	Formulation	Flow	Yearly Imp. of Creditor and Financial Resources	1/Year
Stakeholder	82	Formulation	Flow	Disposal of Creditor Availability	1/Year

Stakeholder	83	GM	Converter	GM: Level of Creditor Expectations	Dimensionless
Stakeholder	84	RC	Converter	R/C: Relations with Creditors	Dimensionless
Stakeholder	85	RC	Converter	R/C: Corporate Financial Strength	Dimensionless
Stakeholder	86	KPI	Converter	RC: Compliance to International Laws and Regulations	Dimensionless
Stakeholder	87	Initial	Converter	Initial: Client Satisfaction and Loyalty	Dimensionless
Stakeholder	88	Initial	Converter	Initial: Reputation	Dimensionless
Stakeholder	89	Initial	Converter	Initial: Creditor and Financial Resource Availability	Dimensionless

Table 83: Model Parameters for Project Management Perspective

Perspective	ID	Conceptual Type	Computerized Type	Parameter	Units
Project Management	90	Formulation	Flow	Budget Gain from Newly Awarded Projects	USD/Years
Project Management	91	KPI	Stock	Total Remaining Project Budget	USD
Project Management	92	Formulation	Flow	Yearly Realized Budget	USD/Years
Project Management	93	KPI	Stock	Total Realized Budget	USD
Project Management	94	Formulation	Converter	Total Estimated Cost to Complete	USD
Project Management	95	Formulation	Converter	Total Earned Budget for Work Performed	USD
Project Management	96	KPI	Converter	Total Cost Variation	USD
Project Management	97	KPI	Converter	Cost Overrun (%)	Dimensionless
Project Management	98	Formulation	Flow	Yearly Project Duration Passed	Dimensionless
Project Management	99	KPI	Stock	Total Realized Project Duration	Years
Project Management	100	Formulation	Converter	Total Earned Duration for Work Performed	Years
Project Management	101	Formulation	Converter	Ave. Schedule Variation	Years

Project Management	102	Formulation	Converter	Ave. Actual Project Duration	Years
Project Management	103	KPI	Converter	Time Management Performance	Dimensionless
Project Management	104	KPI	Converter	Cost Management Performance	Dimensionless
Project Management	105	KPI	Stock	Supply Chain Management Capability	Dimensionless
Project Management	106	Formulation	Flow	Yearly Imp. of Supply Chain Capability	1/Year
Project Management	107	RC	Converter	R/C: Relations with Subcontractor/ Suppliers	Dimensionless
Project Management	108	KPI	Converter	Productivity of Machinery/Equipment	Dimensionless
Project Management	109	GM	Converter	G/M: Market Availability of Material/ Equipment	Dimensionless
Project Management	110	GM	Converter	GM: Competency of Subcontractors/ Suppliers	Dimensionless
Project Management	111	GM	Converter	GM: Market Availability of Labor	Dimensionless
Project Management	112	KPI	Converter	Labor Productivity	Dimensionless
Project Management	113	KPI	Stock	Site Management Capability	Dimensionless
Project Management	114	Formulation	Flow	Yearly Imp of Site Management Capability	1/Year
Project Management	115	KPI	Converter	Quality Management Performance	Dimensionless
Project Management	116	KPI	Stock	Technical Capabilities	Dimensionless
Project Management	117	Formulation	Flow	Yearly Imp of Technical Capability	1/Year
Project Management	118	KPI	Converter	Performance of Design& Engineering	Dimensionless
Project Management	119	GM	Converter	GM: Competency of Designer/ Engineer	Dimensionless
Project Management	120	RC	Converter	RC: Relations with Designer/ Engineers	Dimensionless
Project Management	121	Formulation	Converter	Project Management Soft Skills	Dimensionless
Project Management	122	RC	Converter	RC: Communication & Coordination Management Capability	Dimensionless
Project Management	123	RC	Converter	RC: Integration Management Capability	Dimensionless
Project Management	124	RC	Converter	RC: Scope Management Capability	Dimensionless
Project Management	125	Initial	Converter	Initial: Supply Chain Management Capability	Dimensionless

Project Management	126	Initial	Converter	Initial: Site Management Capability	Dimensionless
Project Management	127	Initial	Converter	Initial: Design and Engineering Capability	Dimensionless
Project Management	128	Initial	Converter	Ave. Planned Project Duration	Years

Table 84: Model Parameters for Governance and Compliance Perspective

Perspective	ID	Conceptual Type	Computerized Type	Parameter	Units
Governance and Compliance	129	KPI	Stock	Contract Management Capability	Dimensionless
Governance and Compliance	130	Formulation	Flow	Yearly Imp. of Contract Management Capability	1/Year
Governance and Compliance	131	Formulation	Flow	Disposal of Contract Management	1/Year
Governance and Compliance	132	KPI	Converter	Claim Mitigation Performance	Dimensionless
Governance and Compliance	133	KPI	Converter	Gains from Claims	USD/Years
Governance and Compliance	134	Initial	Converter	Claim/ Budget Ratio	Dimensionless
Governance and Compliance	135	RC	Converter	RC: Relations with Major Clients	Dimensionless
Governance and Compliance	136	GM	Converter	GM: Maturity of Laws and Regulations	Dimensionless
Governance and Compliance	137	RC	Converter	RC: Performance of Claim/ Dispute Resolution Method	Dimensionless
Governance and Compliance	138	RC	Converter	RC: Performance of Contract Management System	Dimensionless
Governance and Compliance	139	Formulation	Converter	Contract Expenses	USD/Years
Governance and Compliance	140	KPI	Stock	Regulatory Compliance Capability	Dimensionless
Governance and Compliance	141	Formulation	Flow	Yearly Imp. of Regulatory Compliance Capability	1/Year
Governance and Compliance	142	Formulation	Flow	Disposal of Regulatory Compliance	1/Year
Governance and Compliance	143	KPI	Converter	Regulatory Issues Mitigation Performance	Dimensionless
Governance and Compliance	144	Formulation	Converter	Cost of Regulatory Issues	USD/Years

Governance and Compliance	145	Initial	Converter	Regulatory Issues/ Budget Ratio	Dimensionless
Governance and Compliance	146	Formulation	Converter	Regulatory Compliance Expenses	USD/Years
Governance and Compliance	147	RC	Converter	R/C: Relations with Regulatory Bodies	Dimensionless
Governance and Compliance	148	KPI	Stock	Risk Management Capability	Dimensionless
Governance and Compliance	149	Initial	Converter	Project Time Delay Risk Level	Dimensionless
Governance and Compliance	150	Initial	Converter	Project Cost Overrun Risk Level	Dimensionless
Governance and Compliance	151	Formulation	Converter	Residual Delay Risk	Dimensionless
Governance and Compliance	152	Formulation	Converter	Residual Cost Overrun Risk	Dimensionless
Governance and Compliance	153	Formulation	Flow	Disposal of Risk Management	1/Year
Governance and Compliance	154	Formulation	Flow	Yearly Imp. of Risk Management Capabiltiy	1/Year
Governance and Compliance	155	RC	Converter	R/C: Performance of Risk Management System	Dimensionless
Governance and Compliance	156	RC	Converter	R/C: Performance of Internal Control and Audit System	Dimensionless
Governance and Compliance	157	Formulation	Converter	Risk and Audit Expenses	USD/Years
Governance and Compliance	158	Formulation	Converter	RC: Governance and Compliance Capability	Dimensionless
Governance and Compliance	159	Initial	Converter	Initial: Contract Management Capability	Dimensionless
Governance and Compliance	160	Initial	Converter	Initial: Regulatory Compliance Capability	Dimensionless
Governance and Compliance	161	Initial	Converter	Initial: Risk and Audit Capability	Dimensionless
Governance and Compliance	162	GM	Converter	G/M: Strictness of Bureaucracy	Dimensionless

Table 85: Model Parameters for Sustainability Perspective

Perspective	ID	Conceptual Type	Computerized Type	Parameter	Units
Sustainability	163	KPI	Stock	Health and Safety Capability	Dimensionless
Sustainability	164	Formulation	Flow	Yearly Imp. of Health and Safety Capability	1/Year

Sustainability	165	Formulation	Flow	Disposal of HS Capability	1/Year
Sustainability	166	RC	Converter	RC: Performance of H&S training, audit and inspections	Dimensionless
Sustainability	167	RC	Converter	RC: Performance of H&S management system	Dimensionless
Sustainability	168	GM	Converter	GM: Strictness of HS Regulations	Dimensionless
Sustainability	169	Formulation	Converter	Health and Safety Expensses	USD/Years
Sustainability	170	KPI	Converter	Number of Accidents	Employees/Projects
Sustainability	171	Initial	Converter	Ave. Accident/ Employee Ratio	Accidents/Employees
Sustainability	172	KPI	Converter	Number of Fatalities	Employees/Projects
Sustainability	173	Initial	Converter	Project H&S Risk Level	Dimensionless
Sustainability	174	Formulation	Converter	Cost of Poor Heath and Safety	USD/Years
Sustainability	175	Initial	Converter	Ave. Accident Cost	USD/Accidents
Sustainability	176	Initial	Converter	Ave. Fatality Cost	USD/Accidents
Sustainability	177	KPI	Stock	Environmental Capability	Dimensionless
Sustainability	178	Formulation	Flow	Yearly Imp. of Environmental Capability	1/Year
Sustainability	179	RC	Converter	RC: Performance of environmental training, audit and inspections	Dimensionless
Sustainability	180	RC	Converter	RC: Performance of environmental management system	Dimensionless
Sustainability	181	Formulation	Converter	Environmental Expenses	USD/Years
Sustainability	182	Formulation	Flow	Disposal of Environmental Capability	1/Year
Sustainability	183	GM	Converter	GM: Strictness of Environmental Regulations	Dimensionless
Sustainability	184	Formulation	Converter	Targetted Reduction in Energy and Water Consumption	Dimensionless
Sustainability	185	KPI	Converter	Realized Reduction in Energy and Water Consumption	Dimensionless
Sustainability	186	KPI	Converter	Negative Impact from Waste, Dust, Noise Production	Dimensionless
Sustainability	187	Initial	Converter	Project Environmental Risk Level	Dimensionless
Sustainability	188	KPI	Stock	Social Capability	Dimensionless

Sustainability	189	Formulation	Flow	Yearly Imp. of Social Capability	1/Year
Sustainability	190	RC	Converter	RC: Compliance to Human Rights, Equal Employment and Diversity	Dimensionless
Sustainability	191	RC	Converter	RC: Availability of Social Responsibiltiy Initiatives	Dimensionless
Sustainability	192	Formulation	Converter	Social Expenses	USD/Years
Sustainability	193	Formulation	Flow	Disposal of Social Capability	1/Year
Sustainability	194	GM	Converter	GM: Strictness of Social Requirements	Dimensionless
Sustainability	195	KPI	Converter	Impacts to Society & Local Communities	Dimensionless
Sustainability	196	Initial	Converter	Project Social Impact Risk Level	Dimensionless
Sustainability	197	Initial	Converter	Initial: Health and Safety Capability	Dimensionless
Sustainability	198	Initial	Converter	Initial Environmental Capability	Dimensionless
Sustainability	199	Initial	Converter	Initial: Social Capability	Dimensionless
Sustainability	200	Formulation	Converter	RC: Sustainabiltiy Capability	Dimensionless

Table 86: Model Parameters for Learning and Growth Perspective

Perspective	ID	Conceptual Type	Computerized Type	Parameter	Units
Learning and Growth	201	KPI	Stock	Technology & Innovation Capability	Dimensionless
Learning and Growth	202	Formulation	Flow	Yearly Imp. of Technology & Innovation Capability	1/Year
Learning and Growth	203	RC	Converter	R/C: Maturity in Automation and Digitization	Dimensionless
Learning and Growth	204	RC	Converter	R/C: Maturity of IT Applications	Dimensionless
Learning and Growth	205	Formulation	Converter	Technology & Innovation Expenses	USD/Years
Learning and Growth	206	Formulation	Flow	Disposal of Technology Capital	1/Year
Learning and Growth	207	GM	Converter	G/M: Advances in Technology	Dimensionless

Learning and Growth	208	KPI	Converter	Targetted Innovation Initiatives	Number
Learning and Growth	209	KPI	Converter	Implemented Innovation Initiatives	Number
Learning and Growth	210	Formulation	Converter	Gains from Innovation	USD/Years
Learning and Growth	211	Formulation	Converter	Innovation Spending	USD/Years
Learning and Growth	212	GM	Converter	G/M: Benefits Provided for Innovation	Dimensionless
Learning and Growth	213	KPI	Converter	Technology Integration Level	Projects
Learning and Growth	214	KPI	Stock	Knowledge & Intellectual Capability	Dimensionless
Learning and Growth	215	Formulation	Flow	Yearly Imp. of Knowledge Capability	1/Year
Learning and Growth	216	Formulation	Flow	Disposal of Knowledge Capital	1/Year
Learning and Growth	217	RC	Converter	R/C: Organizational Effectiveness	Dimensionless
Learning and Growth	218	RC	Converter	R/C: Organizational Learning	Dimensionless
Learning and Growth	219	Formulation	Converter	Knowledge Capital Expenses	USD/Years
Learning and Growth	220	GM	Converter	G/M: Advances in Organizational Studies	Dimensionless
Learning and Growth	221	KPI	Converter	Number of Post-Project Appraisals	Projects
Learning and Growth	222	Formulation	Stock	Number of Blue Collar Employees	Employees
Learning and Growth	223	Formulation	Flow	Hired Blue Collar Employees	Employees/Years
Learning and Growth	224	Formulation	Converter	Required Blue Collar Employees	Employees/Years
Learning and Growth	225	Initial	Converter	Ave. Number of Blue Collar Employee/ Project	Employees/Projects
Learning and Growth	226	Formulation	Flow	Blue Collar Employee Exists	Employees/Years
Learning and Growth	227	Formulation	Flow	Hired High Skilled Employees	Employees/Years
Learning and Growth	228	KPI	Stock	Number of High Skilled Employees	Employees
Learning and Growth	229	Formulation	Flow	High Skilled Employee Exists	Employees/Years
Learning and Growth	230	Initial	Converter	Ave. Annual Salary Provided to High Skilled Employees	USD
Learning and Growth	231	Formulation	Converter	Total Annual Salary of High Skilled Employees	Employees*USD

Learning and Growth	232	KPI	Converter	% High Skilled Employees	Dimensionless
Learning and Growth	233	Initial	Converter	Ave. Annual Salary Provided to Other White Collar Employees	USD
Learning and Growth	234	Formulation	Converter	Total Annual Salary of Other White Collar Employees	Employees*USD
Learning and Growth	235	Formulation	Flow	Hired White Collar Employees	Employees/Years
Learning and Growth	236	KPI	Stock	Number of White Collar Employees	Employees
Learning and Growth	237	Formulation	Flow	White Collar Employee Exists	Employees/Years
Learning and Growth	238	GM	Converter	G/M: Availability of Skilled Employee	Dimensionless
Learning and Growth	239	Formulation	Converter	Required White Collar Employees	Employees/Years
Learning and Growth	240	Initial	Converter	Ave. Number of White Collar Employee/Project	Employees/Projects
Learning and Growth	241	GM	Converter	G/M: Industry Reputation	Dimensionless
Learning and Growth	242	KPI	Converter	Employee Turnover	Dimensionless
Learning and Growth	243	Formulation	Converter	R/C: Employee Satisfaction and Motivation	Dimensionless
Learning and Growth	244	RC	Converter	R/C: Employee Engagement	Dimensionless
Learning and Growth	245	RC	Converter	R/C: Maturity of HR Applications	Dimensionless
Learning and Growth	246	RC	Converter	R/C: Employee Training	Dimensionless
Learning and Growth	247	Formulation	Converter	Ability to Attract New Employees	Dimensionless
Learning and Growth	248	KPI	Converter	Total Number of Employees	Employees
Learning and Growth	249	Formulation	Converter	Total Annual Salary of White Collar Employees	Employees*USD
Learning and Growth	250	KPI	Stock	Human Capital Capability	Dimensionless
Learning and Growth	251	Formulation	Flow	Yearly Imp of Human Capital	1/year
Learning and Growth	252	Formulation	Flow	Disposal of Human Capital	Dimensionless
Learning and Growth	253	Formulation	Converter	Human Capital Expenses	USD/Years
Learning and Growth	254	GM	Converter	G/M: Advances in HR Applications	Dimensionless
Learning and Growth	255	Formulation	Converter	RC: Learning and Growth Capability	Dimensionless

Learning and Growth	256	Initial	Converter	Initial: Technology & Innovation Capability	Dimensionless
Learning and Growth	257	Initial	Converter	Initial: Knowledge Capability	Dimensionless
Learning and Growth	258	Initial	Converter	Initial: Human Capital	Dimensionless
Learning and Growth	259	Formulation	Converter	Improvement Cost	USD
Learning and Growth	260	Initial	Converter	UnitCost for Medium Level Req. for Org. Competence	USD
Learning and Growth	261	Initial	Converter	Unit Cost for High Level Req. for Org. Competence	USD
Learning and Growth	262	Initial	Converter	Unit Cost for Low Level Req. for Org. Competence	USD
Learning and Growth	263	Formulation	Converter	Year Conversion	Years
Learning and Growth	264	Initial	Converter	Initial: Number of While Collar Employees	Employees
Learning and Growth	265	Initial	Converter	Initial: Number of High Skilled Employees	Employees
Learning and Growth	266	Initial	Converter	Initial: Number of Blue Collar Employees	Employees
Learning and Growth	267	Initial	Converter	Min Number of Blue Collar Employees	Employees
Learning and Growth	268	KPI	Converter	Total Number of Employee Hires	Employees/Years
Learning and Growth	269	KPI	Converter	Total Number of Employee Exists	Employees/Years

APPENDIX 7: MODEL ASSUMPTIONS

ID	Assumption Group	Assumption Description
1	-	Simulation time is defined as 5 years.
2	DC (1) Stock & Flow Formulations for Resource & Capability Accumulations	Resources determine the accumulation or disposal of the capabilities.
3		Capabilities may also dispose or become obsolete due to environmental conditions (global/ market factors).
4	FA1- Importance Weights of Parameters	The relative importance weights are neglected in the model equations.
5	FA2- Rating Conversions	The parameters for Resources& Capabilities, Global & Market Conditions are assigned as -5 / 5 scale in dimensionless unit.
6	FA2- Rating Conversions	In order to convert -5/ 5 scale into some numerical values, a rating conversation (i.e. (50+("R/C: Competitive Advantage"*10)/100) is applied.
7	MA1- Shareholder Revenue	The total revenue/income gained by the company is the sum of revenue gained from construction operations and other operating gains by the support services.
8	MA1- Shareholder Revenue	Project revenue is calculated by the contract markup multiplied by the sum of total budget of newly awarded projects and total budget of initial projects.
9	MA1- Shareholder Revenue	Other operating gains are composed of revenue gained from probable claims and innovation practices of the company.
10	MA2- Contract Markup	Contract markup for the new projects is affected by the contract profit margin and risk-related contingency of the company.
11	MA2- Contract Markup	Risk-related contingency may change based on the changes of how well the company mitigate with its risks. It is calculated by residual cost overrun risk.
12	MA2- Contract Markup	Contract profit margin is calculated by attractiveness of the construction market. If market attractive is high, then companies may foster higher profit marging, or vice versa. However, in each case, contract profit margin can be value between a pre-defined minimum and maximum limits.

13	MA3- Company Expenses	The total expenses made by the company is the sum of its project expenses, general and administrative (G&A) and tax expenses.
14	MA3- Company Expenses	Actual cost of the project is calculated by the sum of total realized budget of projects and total cost variation.
15	MA3- Company Expenses	G&A expenses are about expenses made to improve support services and capabilities of the company. Costs occurred due to any defects or incompliances in regulatory or health and safety issues are also included in the G&A expenses.
16	MA4- Profit/Loss	Net profit is the remaining profit after the G&A expenses, interests or taxes are deducted from the gross profit.
17	MA4- Profit/Loss	Gross profit is the remaining profit after expenses of the project are deducted from the project revenue.
18	MA5- Targeted Budget of Newly Awarded Projects	Targeted budget for new projects are affected by the competitiveness level of the company. If the competitiveness of the company is high, it can enter tenders for the new projects, which are large in size and amount.
19	MA5- Targeted Budget of Newly Awarded Projects	Market attractivess affect the targeted budget of newly awarded projects. If the market is attractive enough, companies can foster for projects having higher budgets.
20	MA5- Targeted Budget of Newly Awarded Projects	Budgets of existing/initial projects are taken as a baseline for the new projects. If competitiveness of the company and attractiveness of the market is so high, companies may foster new projects having budgets so higher than its existing projects.
21	MA6- Complexity	There is a maximum limit for the ongoing projects that the company can execute with its existing resources and capabilities.
22	MA6- Complexity	Complexity of the portfolio is calculated by the number of the ongoing projects divided by the maximum number of projects that can be managed by the company.
23	MA6- Complexity	In case ongoing projects will approach to the manageable number of projects, complexity will increase which in turn influence residual time and cost overrun risk.
24	MA6- Complexity	If the complexity is high, then risk management capability of the company may not be adequate to lower the risk level, remaining residual risk as high.
25	MA6- Complexity	Complexity is also directly related with the unit cost of the improvement of corporate capabilities. Higher complexity may require higher unit cost to improve level of organizational competence.

26	MA7- Market Attractiveness	In case national market conditions are desirable, then company may focus on national market rather than international market, or vice versa.
27	MA7- Market Attractiveness	If attractiveness of national market is higher than international market, then company can target manageable maximum number of projects.
28	MA7- Market Attractiveness	In case the company can target and win tenders in the manageable amount of project, in order to maintain at the safe side, they can target projects that is twice the number of completed projects, only at the first year.
29	MA7- Market Attractiveness	After the first year, company can target manageable amount of projects minus project completion rate.
30	MA7- Market Attractiveness	If attractiveness of the national market is lower than the international market, then company should maintain its national market presence, but focusing more on the international market.
31	MA7- Market Attractiveness	If national market is less attractive than the international market, but still attractive in its own, then company should continue to target new projects at the same number of its previously completed national projects.
32	MA7- Market Attractiveness	If the national market is unattractive, in order to maintain the market presence, the company should target at least the %80 of its previously completed projects in national market.
33	MA8- Competitive Advantage	Competitive advantage is formulated with four parameters; a) Compliance to International Laws and Regulations, b) Client Satisfaction and Loyalty, c) Reputation, and d) Creditor and Financial Resource Availability.
34	MA9- Newly Awarded Projects	When the competitive advantage of the company is low and strength of its competitors is high, then company could not win any new projects.
35	MA9- Newly Awarded Projects	If competitive advantage of the company is high while strength of its competitors is also high, then company could win the half of its targeted projects.
36	MA9- Newly Awarded Projects	If strength of competitors is low while company has high level of competitive advantage, then company can successfully win the projects that it targeted.
37	MA9- Newly Awarded Projects	When the number of ongoing projects of the company reaches its maximum number then company could not enter any tenders to award new projects
38	MA9- Newly Awarded Projects	In addition to the competitive advantage of the company and strength of its competitors, the ability to win new projects is also affected by the extent of the company to make lowest bid.

39	MA9- Newly Awarded Projects	Abiliy to make lowest bid is calculated by the comparison of the contract markup of the company and market average markup. If company can lower its contract markup compared with market average, then it is assumed that it can increase its ability to make lowest bid.
40	MA9- Newly Awarded Projects	Tendering performance represents the extent of company's ability to win tenders in which it entered. It is calculated by yearly total number of newly awarded projects divided by yearly total targeted projects
41	MA10- Ongoing and Completed Projects	Project completions are based on “Ave. Actual Project Duration”.
42	MA11- Project Management Knowledge Areas	Communication and Coordination Management Capability”, “Integration Management Capability, and “Scope Management Capability are assumed to define Managerial Capabilities of the Project Management Organization.
43	MA12- Project Cost Management	Project Cost Management is quantified by Quality Management Performance, Time Management Performance, Client Satisfaction and Loyalty Performance, and overall Learning and Growth Capability of the company
44	MA12- Project Cost Management	Cost Management Performance is utilized when estimating the total earned budget of the company for the work performed.
45	MA12- Project Cost Management	Total cost variation is calculated by subtracting the total realized budget from total earned budget for work performed.
46	MA13- Project Time Management	Project Time Management is quantified by Supply Chain Management Capability, Site Management Capability, and Technical (Design and Engineering) Capability of the Company.
47	MA13- Project Time Management	Time Management Performance is utilized when estimating the total earned duration of the company for the work performed.
48	MA14- Gains from Claims	In each project, there will be such reasons, which in turn provide additional project income from claims as if the claims are managed properly.
49	MA14- Gains from Claims	Claim/budget ratio is added in order to take total amount of probable claims as an average percentage of the yearly-realized budget. It is expected from the company experts to assign a fix percentage for the clam/budget ratio.
50	MA15- Cost of Regulatory Issues	In each project, regulatory issues may rise due to any non-conformities to a specifications, policies, laws and regulations.

51	MA15- Cost of Regulatory Issues	Allowable amount of regulatory issues are taken as an average percentage of budget ratio, which is defined by company experts in the beginning of simulation practice.
52	MA16- Residual Delay/ Cost Overrun Risk	If risk management capability of the company is higher than the complexity born due to the amount of ongoing projects, then company can reduce its risk level in proportion with its risk management capability.
53	MA16- Residual Delay/ Cost Overrun Risk	If complexity is so high or larger than risk management capability of the company, then its capability to manage the risks will not be efficient as expected, ending up the residual risk same with the initial risk level.
54	MA16- Residual Delay/ Cost Overrun Risk	Residual cost overrun risk directly affect "total earned budget of work performed". If cost management performance of the company is medium or low level, then residual cost overrun risk highly affect earned value from work performed.
55	MA16- Residual Delay/ Cost Overrun Risk	If residual cost overrun risk very low, then there is no need to any "risk-related contingency" to the project. However, if residual cost overrun risk so high, then %10 additional contract markup is needed to incorporate "risk-related contingency".
56	MA16- Residual Delay/ Cost Overrun Risk	Residual delay risk is utilized when quantifying the "total earned duration for work performed".
57	MA16- Residual Delay/ Cost Overrun Risk	If residual delay risk is so high and time management performance of the organization is low, then company may not earn any value and have progress on the projects (that is earned duration for work performed), although it spends time to execute the work (that is total realized duration).
58	MA17- Cost of Poor Health and Safety	Each fatality and accident will end up a cost to the company whose unit costs expected to be defined by company experts in the beginning of simulation practice.
59	MA18- Number of Fatalities & Accidents	In each project, accidents or fatalities may occur due to poor health and safety (H&S) management capability or high H&S risks inherent in the projects.
60	MA18- Number of Fatalities & Accidents	There are an average number of accidents per total number of employees, which are defined by company experts as an input ratio.
61	MA18- Number of Fatalities & Accidents	Accidents or fatalities can occur only for blue-collar employees, as they are more prone to H&S risk due to nature of the works.
62	MA18- Number of Fatalities & Accidents	Number of accidents is assumed directly proportional with project H&S risk level and adversely proportional with health and safety capability of the company.

63	MA18- Number of Fatalities & Accidents	%5 of the accidents can turned into fatalities, in order words fatalities is taken as a fix percentage of the number of accidents.
64	MA19- Level of Negative Sustainability Impacts	In each project, negative environmental or social impacts may occur due to poor environmental management or social responsibility capability of the company.
65	MA20- Reduction in Energy and Water Consumption	In each project, some reductions in energy and water consumptions will be targeted.
66	MA20- Reduction in Energy and Water Consumption	Targeted reduction in energy and water consumption is directly proportional with the strictness of environmental regulations. The maximum realistic reduction in consumption is assumed as %30.
67	MA20- Reduction in Energy and Water Consumption	If the environmental capability of the company is too high, then it can successfully realize the reduction in the same amount it targeted.
68	MA21- Ability to Attract New Employees	Employee recruitment of the company is dependent on its ability to attract new employees.
69	MA21- Ability to Attract New Employees	If global demand for construction is medium to high level while strength of international competitors is also high, or if national demand for construction is medium to high level while strength of national competitors are high, then company may not attract new employees with the same of rate of its competitive advantage. In this case, its ability to attract new employees is the proportion of its competitive advantage to strength of its competitors.
70	MA21- Ability to Attract New Employees	In case, strength of its competitors is not so high, then company can utilize its competitive advantage fully to attract new employees.
71	MA22- Employee Hires and Exists	Number of white-collar, blue collar and high skilled employees as well as average number of blue collar and white-collar employees/project are the five major input/ initial values those are defined by the company experts.
72	MA22- Employee Hires and Exists	These initials are utilized for each project, independent from the size, complexity and duration of project. Thus, the effect of project attributes on the employee number is ignored.
73	MA22- Employee Hires and Exists	As the budget of blue-collar employee has already included in the project budget, there is no need to allocate additional financial resource for blue-collar employee. Thus, the company can hire exactly the same amount of required blue-collar employee.

74	MA22- Employee Hires and Exists	Blue-collar employees exist when the projects are finished. Although all the projects executed by the company has finished, still “a minimum number blue collar employee", is continue to work, in order to maintain these employees for forthcoming projects.
75	MA22- Employee Hires and Exists	If the total number of newly awarded projects is higher than the total ongoing projects of the company, then the company requires hiring new white-collar employees. The number of new hires is quantified by total number of employees required for the new projects minus the existing number of white-collar employees.
76	MA22- Employee Hires and Exists	If newly awarded projects is lower than the ongoing projects of the company, then company will not hire any additional new employee.
77	MA22- Employee Hires and Exists	Company could hire new white-collar employees if skilled employee is available in the market, if the reputation of the industry is high and company is attractive enough to hire new employees.
78	MA22- Employee Hires and Exists	White-collar employee exists are unavoidable as there can be an employee turnover due to dissatisfaction of employees. Thus, independent from whether the company could win new projects, a number of employee exists is considered directly proportional to the employee turnover.
79	MA22- Employee Hires and Exists	There will be additional exists due to completion of projects. If the number of newly awarded projects is smaller than the total ongoing projects then company will want to make employees exist with the number of completed projects.
80	MA22- Employee Hires and Exists	Company can also attract high skilled employees if it has good reputation across the industry.
81	MA22- Employee Hires and Exists	Company aimed to achieve high skilled employee at the %10 of its existing white collar employees, as high skilled employees are beneficial for corporate effectiveness but in the same time they requires higher amount of annual salary compared with other employees.
82	MA22- Employee Hires and Exists	High skilled employees can also exist due to dissatisfaction, which lead to employee turnover.
83	MA23- Innovation Spending and Revenue from Innovation	Company can gain revenue by innovation through either cost cutting or new earnings. The company needs to allocate some financial source for innovation in order to enhance its innovation capability.
84	MA23- Innovation Spending and Revenue from Innovation	In each project, the company will spend on innovation at a percent of its yearly-realized budget.

85	MA23- Innovation Spending and Revenue from Innovation	If benefits provided for innovation by government or any other external agencies are high, %1 of its yearly-realized budget is sufficient for the company to spend innovation initiatives.
86	MA23- Innovation Spending and Revenue from Innovation	If benefits provided are low, then company should invest innovation by its own resources, which are assumed to as %3 of the yearly-realized budget.
87	MA24- Implemented Innovation Initiatives	In each project, company will foster for innovation through some initiatives made by the company employees.
88	MA24- Implemented Innovation Initiatives	If advances in technology in the market are high then the company will target 10 innovation initiatives per year. If the advances in technology are medium level, then company will target 8 initiatives, and independent from the advances in the market, company will target at least 5 initiatives in order to enhance its technology and innovation capability.
89	MA25- Post- Project Appraisals	The numbers of post-project appraisals are quantified by multiplying of total completed projects to knowledge and intellectual capability.

APPENDIX 8: MODEL EQUATIONS

Table 87: Model Equations for Financial Perspective

ID	P1: Financial Perspective:	Assumption ID
1	Total Project Revenue(t) = Total Project Revenue(t - dt) + (Yearly Project Revenue) * dt	MA1
2	Yearly Project Revenue = (1+(Contract Markup/100))*((Yearly Total Budget of Newly Awarded Projects)+Total Budget of Initial Projects)	MA1
3	Total Shareholder Revenue(t) = Total Shareholder Revenue(t - dt) + (Yearly Shareholder Revenue) * dt	MA1
4	Yearly Shareholder Revenue = Yearly Project Revenue +Yearly Other Operating Gains	MA1
5	Other Operating Gains(t) = Other Operating Gains(t - dt) + (Yearly Other Operating Gains) * dt	MA1
6	Yearly Other Operating Gains = Gains from Claims +Gains from Innovation	MA1
7	Contract Markup = Contract Profit Margin +"Risk-Related Contingency"	MA2
8	Contract Profit Margin = Min Limit for Contract Profit Margin+((50+(0,5*Attractiveness of National Construction Market+0,5*Attractiveness of International Construction Market)*10)*(Max Limit for Contract Profit Margin-Min Limit for Contract Profit Margin)/100)	MA2
9	"Risk-Related Contingency" = IF (Residual Cost Overrun Risk=1) THEN 0 ELSE (Residual Cost Overrun Risk/50*100)	MA2
10	Total Company Expenses(t) = Total Company Expenses(t - dt) + (Yearly Company Expenses) * dt	MA3
11	Yearly Company Expenses = Yearly G&A Expenses +Yearly Project Expenses +Tax Expenses	MA3
12	Total General & Administrative Expenses(t) = Total General & Administrative Expenses(t - dt) + (Yearly G&A Expenses) * dt	MA3
13	Yearly G&A Expenses = Knowledge Capital Expenses +Health and Safety Expenses +Environmental Expenses +Social Expenses +Risk and Audit Expenses +Contract Expenses +Regulatory Compliance Expenses +Technology & Innovation Expenses +Cost of Poor Health and Safety +Innovation Spending +Cost of Regulatory Issues +Human Capital Expenses	MA3
14	Tax Expenses = IF (TIME>1) THEN (Yearly Realized Budget*VAT %*0,6) ELSE 0	
15	Total Project Expenses(t) = Total Project Expenses(t - dt) + (Yearly Project Expenses) * dt	MA3
16	Yearly Project Expenses = Total Budget of Initial Projects+ (Yearly Total Budget of Newly Awarded Projects)+ (IF (TIME >1) THEN Total Cost Variation/Total Realized Project Duration ELSE 0)	MA3

17	Gross Profit Margin = IF (TIME >1) THEN (IF (Yearly Project Revenue>0) THEN (Yearly Gross Profit/Yearly Project Revenue)*100 ELSE 0) ELSE 0	MA4
18	Net Profit Margin = IF (TIME>1) THEN (IF (Yearly Shareholder Revenue>0) THEN (Yearly Net Profit/Yearly Shareholder Revenue)*100 ELSE 0) ELSE 0	MA4
19	Total Gross Profit(t) = Total Gross Profit(t - dt) + (Yearly Gross Profit) * dt	MA4
20	Total Net Profit(t) = Total Net Profit(t - dt) + (Yearly Net Profit) * dt	MA4
21	Yearly Gross Profit = Yearly Project Revenue-Yearly Project Expenses	MA4
22	Yearly Net Profit = Yearly Shareholder Revenue-Yearly Company Expenses	MA4
23	Targeted Budget of Potential International Projects = Initial Budget International Projects*((50+("R/C: Competitive Advantage"*10))/50)*((50+(Attractiveness of International Construction Market*10))/50)	MA5, FA2
24	Targeted Budget of Potential National Projects = Initial Budget of National Projects*((50+("R/C: Competitive Advantage"*10))/50)*((50+(Attractiveness of National Construction Market*10))/50)	MA5, FA2
25	Total Budget of Initial Projects = IF (TIME<=2) THEN ((Initial Ongoing National Projects*Initial Budget of National Projects)+(Initial Ongoing International Projects*Initial Budget International Projects))/"Ave. Actual Project Duration" ELSE 0	MA5
26	Yearly Budget of Newly Awarded International Projects = Targeted Budget of Potential International Projects*Newly Awarded International Projects	MA5
27	Yearly Budget of Newly Awarded National Projects = Targeted Budget of Potential National Projects*Newly Awarded National Projects	MA5
28	Yearly Total Budget of Newly Awarded Projects = Yearly Budget of Newly Awarded National Projects +Yearly Budget of Newly Awarded International Projects	MA5

Table 88: Model Equations for Market and Business Growth Perspective

ID	P2: Market and Business Growth Perspective:	Assumption ID
29	Complexity = ((Total Ongoing Projects/ (Manageable Max Number of National Projects +Manageable Max Number of International Projects))*5)/Year Conversion	MA6

30	Improvement Cost = IF(Complexity>=0,7) THEN "Unit Cost for High Level Req. for Org. Competence" ELSE (IF(Complexity<0,7 AND Complexity>=0,4) THEN "Unit Cost for Medium Level Req. for Org. Competence" ELSE "Unit Cost for Low Level Req. for Org. Competence")	MA6, DC1
31	Attractiveness of International Construction Market = ("G/M: Global Economic Growth and Development" +"G/M: Favorability of International Relations" +"G/M: Global Demand" +"G/M: Global Political Stability")/4	MA7, FA1
32	Attractiveness of National Construction Market = ("G/M: Country Political Stability" +"G/M: Country Economic Growth and Development" +"G/M: National Demand")/3	MA7, FA1
33	Targeted Number of International Projects = IF Attractiveness of International Construction Market>=0 AND Attractiveness of National Construction Market>=0 THEN (IF(Attractiveness of International Construction Market-Attractiveness of National Construction Market>=0) THEN (IF TIME >1 THEN (Manageable Max Number of International Projects -International Projects Completion Rate)*0,7 ELSE International Projects Completion Rate*2) ELSE International Projects Completion Rate) ELSE International Projects Completion Rate*0,8	MA7
34	Targeted Number of National Projects = IF Attractiveness of National Construction Market>=0 AND Attractiveness of International Construction Market>=0 THEN (IF(Attractiveness of National Construction Market-Attractiveness of International Construction Market>=0) THEN (IF TIME>1 THEN (Manageable Max Number of National Projects -National Projects Completion Rate)*0,7 ELSE National Projects Completion Rate*2) ELSE National Projects Completion Rate) ELSE National Projects Completion Rate*0,8	MA7
35	"R/C: Competitive Advantage" = (Client Satisfaction and Loyalty+ "Reputation (for other stakeholders)"+Creditor and Financial Resource Availability +RC: Compliance to International Laws and Regulations)/4	MA8, FA1
36	Newly Awarded International Projects = IF((Ongoing International Projects/Year Conversion)<=Manageable Max Number of International Projects) THEN (IF ("R/C: Competitive Advantage"<0 AND "G/M: Strength of International Competitors">"R/C: Competitive Advantage") THEN 0 ELSE ((Targeted Number of International Projects-International Projects Completion Rate)*("R/C: Ability to Make Lowest Bid" +"R/C: Competitive Advantage")/5)) ELSE 0	MA9
37	Newly Awarded National Projects = IF((Ongoing National Projects/Year Conversion)<=Manageable Max Number of National Projects) THEN (IF ("R/C: Competitive Advantage"<0 AND "G/M: Strength of National Competitors">"R/C: Competitive Advantage") THEN 0 ELSE ((Targeted Number of National Projects-National Projects Completion Rate)*("R/C: Ability to Make Lowest Bid" +"R/C: Competitive Advantage")/5)) ELSE 0	MA9
38	"R/C: Ability to Make Lowest Bid" = (IF (Contract Markup >=5 AND Contract Markup<="Market Ave. Contract Markup") THEN ("Market Ave. Contract Markup"-Contract Markup) ELSE 5) AND (IF (Contract Markup <=20) AND Contract Markup >"Market Ave. Contract Markup" THEN (Contract Markup-"Market Ave. Contract Markup")/2 ELSE -5)	MA9

39	Tendering Performance = Yearly Total Newly Awarded Projects/Yearly Total Targeted Projects*100	MA9
40	Yearly Total Newly Awarded Projects = Newly Awarded National Projects +Newly Awarded International Projects	MA9
41	Yearly Total Targeted Projects = Targeted Number of National Projects +Targeted Number of International Projects	MA9
42	Ongoing International Projects(t) = Ongoing International Projects(t - dt) + (Newly Awarded International Projects - International Projects Completion Rate) * dt	MA10
43	International Projects Completion Rate = Ongoing International Projects/"Ave. Actual Project Duration"	MA10
44	Completed International Projects(t) = Completed International Projects(t - dt) + (International Projects Completion Rate) * dt	MA10
45	Ongoing National Projects(t) = Ongoing National Projects(t - dt) + (Newly Awarded National Projects - National Projects Completion Rate) * dt	MA10
46	National Projects Completion Rate = Ongoing National Projects/"Ave. Actual Project Duration"	MA10
47	Completed National Projects(t) = Completed National Projects(t - dt) + (National Projects Completion Rate) * dt	MA10
48	Total Completed Projects = Completed National Projects +Completed International Projects	MA10
49	Total Ongoing Projects = Ongoing National Projects +Ongoing International Projects	MA10
50	Yearly Project Completion = National Projects Completion Rate +International Projects Completion Rate	MA10

Table 89: Model Equations for Stakeholder Perspective

ID	P3: Stakeholder Perspective:	Assumption ID
51	Client Retention Rate = (-(Client Satisfaction and Loyalty *10)+50)/20	FA2
52	Client Satisfaction and Loyalty(t) = Client Satisfaction and Loyalty(t - dt) + (Yearly Imp of Client Satisfaction - Disposal of Client Satisfaction) * dt	DC1
53	Yearly Imp of Client Satisfaction = IF(Client Satisfaction and Loyalty +((Cost Management Performance +RC: Relations with Major Clients +RC: Sustainability Capability +RC: Governance and Compliance Capability)/4)<=5) THEN ((Cost Management Performance +RC: Relations with Major Clients +RC: Sustainability Capability +RC: Governance and Compliance Capability)/4)/"Ave. Actual Project Duration" ELSE ((5-Client Satisfaction and Loyalty)/"Ave. Actual Project Duration")	DC1
54	Disposal of Client Satisfaction = IF (Client Satisfaction and Loyalty>=5) THEN 0 ELSE (IF(Client Satisfaction and Loyalty<=-5) THEN 0 ELSE Client Satisfaction and Loyalty*((50+("G/M: Level of Client Expectations"*10))/100)/"Ave. Actual Project Duration")	DC1

55	Creditor and Financial Resource Availability (t) = Creditor and Financial Resource Availability (t - dt) + ("Yearly Imp. of Creditor and Financial Resources" - Disposal of Creditor Availability) * dt	DC1
56	"Yearly Imp. of Creditor and Financial Resources" = IF(Creditor and Financial Resource Availability+(("R/C: Relations with Creditors" +"Reputation (for other stakeholders)"+"R/C: Corporate Financial Strength" +RC: Sustainability Capability +RC: Governance and Compliance Capability)/5)<=5) THEN (("R/C: Relations with Creditors" +"Reputation (for other stakeholders)"+"R/C: Corporate Financial Strength" +RC: Sustainability Capability +RC: Governance and Compliance Capability)/5)/"Ave. Actual Project Duration" ELSE (5-Creditor and Financial Resource Availability)/"Ave. Actual Project Duration"	DC1
57	Disposal of Creditor Availability = IF (Creditor and Financial Resource Availability>=5) THEN 0 ELSE (IF(Creditor and Financial Resource Availability<=-5) THEN 0 ELSE Creditor and Financial Resource Availability*((50+(GM: Level of Creditor Expectations*10))/100)/"Ave. Actual Project Duration")	DC1
58	RC: Compliance to International Laws and Regulations = (Regulatory Compliance Capability +Risk Management Capability +Health and Safety Capability +Environmental Capability +Social Capability)/5	FA1
59	"Reputation (for other stakeholders)"(t) = "Reputation (for other stakeholders)"(t - dt) + ("Yearly Imp. of Reputation" - Disposal of Reputation) * dt	DC1
60	"Yearly Imp. of Reputation" = IF("Reputation (for other stakeholders)"+((Client Satisfaction and Loyalty +"R/C: Relations with Media" +"R/C: Relations with Regulatory Bodies" +RC: Sustainability Capability +RC: Governance and Compliance Capability)/5)<=5) THEN ((Client Satisfaction and Loyalty +"R/C: Relations with Media" +"R/C: Relations with Regulatory Bodies" +RC: Sustainability Capability +RC: Governance and Compliance Capability)/5)/"Ave. Actual Project Duration" ELSE (5-"Reputation (for other stakeholders)")/"Ave. Actual Project Duration"	DC1
61	Disposal of Reputation = IF ("Reputation (for other stakeholders)">=5) THEN 0 ELSE (IF("Reputation (for other stakeholders)"<=-5) THEN 0 ELSE ("Reputation (for other stakeholders)"*((50+(("G/M: Power of Media" +"G/M: Level of Society Demands")/2)*10))/100)/"Ave. Actual Project Duration")	DC1

Table 90: Model Equations for Project Management Perspective

ID	P4: Project Management Perspective:	Assumption ID
62	Cost Management Performance = (Time Management Performance +Quality Management Performance +Client Satisfaction and Loyalty +RC: Learning and Growth Capability)/4	MA11, FA1

63	Project Management Soft Skills = (RC: Communication & Coordination Management Capability +RC: Integration Management Capability +RC: Scope Management Capability)/3	MA11, FA1
64	Quality Management Performance = (Supply Chain Management Capability +Site Management Capability +Technical Capabilities)/3	MA11, FA1
65	Time Management Performance = (Supply Chain Management Capability +Site Management Capability +Technical Capabilities)/3	MA11, FA1
66	Total Remaining Project Budget(t) = Total Remaining Project Budget(t - dt) + (Budget Gain from Newly Awarded Projects - Yearly Realized Budget) * dt	MA12
67	INIT Total Remaining Project Budget = INIT((Initial Ongoing National Projects*Initial Budget of National Projects)+(Initial Ongoing International Projects*Initial Budget International Projects))	MA12
68	Total Cost Variation = Total Realized Budget-Total Earned Budget for Work Performed	MA12
69	"Cost Overrun (%)" = IF (Total Cost Variation>0) THEN (IF (TIME>1) THEN Total Cost Variation/Total Realized Budget*100 ELSE 0) ELSE 0	MA12
70	Total Estimated Cost to Complete = Total Realized Budget-Total Earned Budget for Work Performed +Total Remaining Project Budget	MA12
71	Total Realized Budget(t) = Total Realized Budget(t - dt) + (Yearly Realized Budget) * dt	MA12
72	Yearly Realized Budget = Total Remaining Project Budget/"Ave. Planned Project Duration"	MA12
73	Total Earned Budget for Work Performed = IF Cost Management Performance>=3 THEN Total Realized Budget*((50+((Cost Management Performance)*10))/100) ELSE Total Realized Budget*((50+((Cost Management Performance/Residual Cost Overrun Risk)*10))/100)	MA12, FA2
74	Budget Gain from Newly Awarded Projects = Yearly Budget of Newly Awarded National Projects +Yearly Budget of Newly Awarded International Projects	MA12
75	Yearly Realized Budget = Total Remaining Project Budget/"Ave. Planned Project Duration"	MA12
76	"Ave. Actual Project Duration" = ("Ave. Planned Project Duration" +"Ave. Schedule Variation")	MA13
77	"Ave. Schedule Variation" = Total Realized Project Duration-Total Earned Duration for Work Performed	MA13
78	Total Earned Duration for Work Performed = IF Time Management Performance>=3 THEN Total Realized Project Duration*((50+((Time Management Performance)*10))/100) ELSE Total Realized Project Duration*(50+((Time Management Performance/Residual Delay Risk)*10))/100	MA13, FA2
79	Total Realized Project Duration(t) = Total Realized Project Duration(t - dt) + (Yearly Project Duration Passed) * dt	MA13
80	Labor Productivity = (Site Management Capability +GM: Market Availability of Labor +"GM: Competency of Subcontractors/ Suppliers")/3	FA1

81	Performance of Design& Engineering = (Technical Capabilities +"GM: Competency of Designer/ Engineer")/2	FA1
82	"Productivity of Machinery/Equipment" = ("GM: Competency of Subcontractors/ Suppliers" +Supply Chain Management Capability +"G/M: Market Availability of Material/ Equipment")/3	FA1
83	Site Management Capability(t) = Site Management Capability(t - dt) + (Yearly Imp of Site Management Capability) * dt	DC1
84	Yearly Imp of Site Management Capability = IF(Site Management Capability + ((Health and Safety Capability +Supply Chain Management Capability +Technical Capabilities +RC: Learning and Growth Capability +Project Management Soft Skills)/5)<=5) THEN ((Health and Safety Capability +Supply Chain Management Capability +Technical Capabilities +RC: Learning and Growth Capability +Project Management Soft Skills)/5/"Ave. Actual Project Duration") ELSE (5-Site Management Capability)/"Ave. Actual Project Duration"	FA1, DC1
85	Supply Chain Management Capability (t) = Supply Chain Management Capability (t - dt) + ("Yearly Imp. of Supply Chain Capability") * dt	DC1
86	"Yearly Imp. of Supply Chain Capability" = IF(Supply Chain Management Capability + ((Contract Management Capability +Technical Capabilities +"R/C: Relations with Subcontractor/ Suppliers" +RC: Learning and Growth Capability +Project Management Soft Skills)/5)<=5) THEN (Contract Management Capability +Technical Capabilities +"R/C: Relations with Subcontractor/ Suppliers" +RC: Learning and Growth Capability +Project Management Soft Skills)/5/"Ave. Actual Project Duration" ELSE (5-Supply Chain Management Capability)/"Ave. Actual Project Duration"	FA1, DC1
87	Technical Capabilities(t) = Technical Capabilities(t - dt) + (Yearly Imp of Technical Capability) * dt	DC1
88	Yearly Imp of Technical Capability = IF (Technical Capabilities<=-5) THEN 0 ELSE (IF (Technical Capabilities + (Regulatory Compliance Capability +Technical Capabilities +RC: Learning and Growth Capability +"RC: Relations with Designer/ Engineers" +Project Management Soft Skills)/5<=5) THEN ((Regulatory Compliance Capability +Technical Capabilities +RC: Learning and Growth Capability +"RC: Relations with Designer/ Engineers" +Project Management Soft Skills)/5/"Ave. Actual Project Duration") ELSE (5-Technical Capabilities)/"Ave. Actual Project Duration")	FA1, DC1

Table 91: Model Equations for Governance and Compliance Perspective

ID	**P5: Governance and Compliance Perspective :**	**Assumption ID**
89	Gains from Claims = Yearly Realized Budget*"Claim/ Budget Ratio"*((50+(Claim Mitigation Performance*10))/100)	MA14, FA2

90	Cost of Regulatory Issues = Yearly Total Budget of Newly Awarded Projects*"Regulatory Issues/ Budget Ratio"*((50-(Regulatory Issues Mitigation Performance*10))/100)	MA15, FA2
91	Residual Cost Overrun Risk = IF(Risk Management Capability>=Complexity) THEN (Project Cost Overrun Risk Level-(((Risk Management Capability-Complexity)/10)*(Project Cost Overrun Risk Level-1))) ELSE Project Cost Overrun Risk Level	MA16
92	Residual Delay Risk = IF(Risk Management Capability>=Complexity) THEN (Project Time Delay Risk Level-(((Risk Management Capability-Complexity)/10)*(Project Time Delay Risk Level-1))) ELSE Project Time Delay Risk Level	MA16
93	RC: Governance and Compliance Capability = (Contract Management Capability +Regulatory Compliance Capability +Risk Management Capability)/3	FA2
94	Contract Management Capability (t) = Contract Management Capability (t - dt) + ("Yearly Imp. of Contract Management Capability" - Disposal of Contract Management) * dt	DC1
95	"Yearly Imp. of Contract Management Capability" = IF (Contract Management Capability<=-5) THEN 0 ELSE (IF(Contract Management Capability + (("RC: Performance of Claim/ Dispute Resolution Method" +RC: Performance of Contract Management System +Regulatory Issues Mitigation Performance +RC: Learning and Growth Capability)/4) <=5) THEN (("RC: Performance of Claim/ Dispute Resolution Method" +RC: Performance of Contract Management System +Regulatory Issues Mitigation Performance +RC: Learning and Growth Capability)/4/"Ave. Actual Project Duration") ELSE (5-Contract Management Capability)/"Ave. Actual Project Duration")	DC1, FA1
96	Disposal of Contract Management = IF (Contract Management Capability>=5) THEN 0 ELSE (IF(Contract Management Capability<=-5) THEN 0 ELSE (Contract Management Capability*((50+(("G/M: Level of Client Expectations" +Complexity)/2)*10))/100)/"Ave. Actual Project Duration")	DC1
97	Contract Expenses = IF ("Yearly Imp. of Contract Management Capability">0) THEN ("Yearly Imp. of Contract Management Capability"*Improvement Cost) ELSE 0	DC1
98	Claim Mitigation Performance = (0,5*Contract Management Capability +0,25*GM: Maturity of Laws and Regulations+0,25*RC: Relations with Major Clients)	FA1
99	Regulatory Compliance Capability (t) = Regulatory Compliance Capability (t - dt) + ("Yearly Imp. of Regulatory Compliance Capability" - Disposal of Regulatory Compliance) * dt	DC1
100	"Yearly Imp. of Regulatory Compliance Capability" = IF (Regulatory Compliance Capability<=-5) THEN 0 ELSE (IF(Regulatory Compliance Capability + ("R/C: Relations with Regulatory Bodies" +Risk Management Capability +RC: Learning and Growth Capability +RC: Sustainability Capability)/4<=5) THEN (("R/C: Relations with Regulatory Bodies" +Risk Management Capability +RC: Sustainability Capability)/4/"Ave. Actual Project Duration") ELSE (5-Regulatory Compliance Capability)/"Ave. Actual Project Duration")	DC1, FA1

101	Disposal of Regulatory Compliance = IF (Regulatory Compliance Capability>=5) THEN 0 ELSE (IF(Regulatory Compliance Capability<=-5) THEN 0 ELSE (Regulatory Compliance Capability*((50+(("G/M: Strictness of Bureaucracy" +Complexity)/2)*10))/100)/"Ave. Actual Project Duration")	DC1
102	Regulatory Compliance Expenses = IF ("Yearly Imp. of Regulatory Compliance Capability">0) THEN ("Yearly Imp. of Regulatory Compliance Capability"*Improvement Cost) ELSE 0	DC1
103	Regulatory Issues Mitigation Performance = ("G/M: Country Political Stability" +"G/M: Global Political Stability" +Regulatory Compliance Capability +GM: Maturity of Laws and Regulations)/5	FA2
104	Risk Management Capability (t) = Risk Management Capability (t - dt) + ("Yearly Imp. of Risk Management Capability" - Disposal of Risk Management) * dt	DC1
105	"Yearly Imp. of Risk Management Capability" = IF (Risk Management Capability<=-5) THEN 0 ELSE (IF(Risk Management Capability+ ("R/C: Performance of Risk Management System" +"R/C: Performance of Internal Control and Audit System" +RC: Learning and Growth Capability +RC: Sustainability Capability)/5)<=5 THEN ("R/C: Performance of Risk Management System" +"R/C: Performance of Internal Control and Audit System" +RC: Learning and Growth Capability +RC: Sustainability Capability)/4/"Ave. Actual Project Duration" ELSE (5-Risk Management Capability)/"Ave. Actual Project Duration")	DC1
106	Disposal of Risk Management = IF (Risk Management Capability>=5) THEN 0 ELSE (IF(Risk Management Capability<=-5) THEN 0 ELSE Risk Management Capability*((50+(Complexity*10))/100)/"Ave. Actual Project Duration")	DC1
107	Risk and Audit Expenses = IF ("Yearly Imp. of Risk Management Capability">0) THEN ("Yearly Imp. of Risk Management Capability"*Improvement Cost) ELSE 0	DC1

Table 92: Model Equations for Sustainability Perspective

ID	P6: Sustainability Perspective:	Assumption ID
108	RC: Sustainability Capability = (Health and Safety Capability +Environmental Capability +Social Capability)/3	FA1
109	Health and Safety Capability (t) = Health and Safety Capability (t - dt) + ("Yearly Imp. of Health and Safety Capability" - Disposal of HS Capability) * dt	DC1

110	"Yearly Imp. of Health and Safety Capability" = IF (Health and Safety Capability+ (+RC: Performance of H&S management system +"RC: Performance of H&S training, audit and inspections" +RC: Governance and Compliance Capability +RC: Learning and Growth Capability)/4)<=5 THEN ((+RC: Performance of H&S management system +"RC: Performance of H&S training, audit and inspections" +RC: Governance and Compliance Capability +RC: Learning and Growth Capability)/4/"Ave. Actual Project Duration") ELSE (5-Health and Safety Capability)/"Ave. Actual Project Duration"	DC1
111	Disposal of HS Capability = IF (Health and Safety Capability>=5) THEN 0 ELSE (IF(Health and Safety Capability<=-5) THEN 0 ELSE Health and Safety Capability*((50+(GM: Strictness of HS Regulations*10))/100)/"Ave. Actual Project Duration")	DC1
112	Health and Safety Expenses = IF("Yearly Imp. of Health and Safety Capability">0) THEN ("Yearly Imp. of Health and Safety Capability"*Improvement Cost) ELSE 0	DC1
113	Cost of Poor Health and Safety = ((Number of Fatalities*"Ave. Fatality Cost")+(Number of Accidents*"Ave. Accident Cost"))*(Total Ongoing Projects/Year Conversion)	MA17, FA2
114	Number of Fatalities = IF(Health and Safety Capability<0) THEN Number of Accidents*0,05 ELSE 0	MA18
115	Number of Accidents = "Ave. Accident/ Employee Ratio"*"Ave. Number of Blue Collar Employee/ Project"*((50-(Health and Safety Capability*10))/100)*Project H&S Risk Level	MA18, FA2
116	Environmental Capability (t) = Environmental Capability (t - dt) + ("Yearly Imp. of Environmental Capability" - Disposal of Environmental Capability) * dt	DC1
117	"Yearly Imp. of Environmental Capability" = IF(Environmental Capability+ ("RC: Performance of environmental training, audit and inspections" +RC: Performance of environmental management system +RC: Governance and Compliance Capability +RC: Learning and Growth Capability/4) <=5) THEN (("RC: Performance of environmental training, audit and inspections" +RC: Performance of environmental management system +RC: Governance and Compliance Capability +RC: Learning and Growth Capability)/4/"Ave. Actual Project Duration") ELSE (5-Environmental Capability)/"Ave. Actual Project Duration"	DC1
118	Disposal of Environmental Capability = IF (Environmental Capability>=5) THEN 0 ELSE (IF(Environmental Capability<=-5) THEN 0 ELSE Environmental Capability*((50+(GM: Strictness of Environmental Regulations*10))/100)/"Ave. Actual Project Duration")	DC1
119	Environmental Expenses = IF("Yearly Imp. of Environmental Capability">0) THEN ("Yearly Imp. of Environmental Capability"*Improvement Cost) ELSE 0	DC1
120	"Negative Impact from Waste, Dust, Noise Production" = Project Environmental Risk Level*(-50+(Environmental Capability*10))/100	MA19, FA2
121	Targeted Reduction in Energy and Water Consumption = 30*(50+(GM: Strictness of Environmental Regulations*10))/100	MA20

122	Realized Reduction in Energy and Water Consumption = Targeted Reduction in Energy and Water Consumption*(50+(Environmental Capability*10))/100	MA20, FA2
123	Social Capability (t) = Social Capability (t - dt) + ("Yearly Imp. of Social Capability" - Disposal of Social Capability) * dt	DC1
124	"Yearly Imp. of Social Capability" = IF(Social Capability+ (RC: Availability of Social Responsibility Initiatives +"RC: Compliance to Human Rights, Equal Employment and Diversity" +RC: Governance and Compliance Capability +RC: Learning and Growth Capability)/4 <=5) THEN (RC: Availability of Social Responsibility Initiatives +"RC: Compliance to Human Rights, Equal Employment and Diversity" +RC: Governance and Compliance Capability +RC: Learning and Growth Capability)/4/"Ave. Actual Project Duration" ELSE (5-Social Capability)/"Ave. Actual Project Duration"	DC1
125	Disposal of Social Capability = IF (Social Capability>=5) THEN 0 ELSE (IF(Social Capability<=-5) THEN 0 ELSE Social Capability*((50+(GM: Strictness of Social Requirements*10))/100)/"Ave. Actual Project Duration")	DC1
126	Social Expenses = IF("Yearly Imp. of Social Capability">0) THEN ("Yearly Imp. of Social Capability"*Improvement Cost) ELSE 0	DC1
127	Impacts to Society & Local Communities = Project Social Impact Risk Level*(-50+(Social Capability*10))/100	MA19, FA2

Table 93: Model Equations for Learning and Growth Perspective

ID	P7: Learning and Growth Perspective:	Assumption ID
128	Ability to Attract New Employees = IF (("G/M: Global Demand">0 AND "G/M: Strength of International Competitors">0) OR ("G/M: National Demand">0 AND "G/M: Strength of National Competitors">0)) THEN "R/C: Competitive Advantage"/ (("G/M: Strength of International Competitors" +"G/M: Strength of National Competitors")/2) ELSE "R/C: Competitive Advantage"	MA21
129	"R/C: Employee Satisfaction and Motivation" = ("R/C: Employee Engagement" +"R/C: Maturity of HR Applications" +"R/C: Employee Training")/3	FA1
130	RC: Learning and Growth Capability = (Technology & Innovation Capability +Knowledge & Intellectual Capability +Human Capital Capability)/3	FA1
131	Employee Turnover = -("R/C: Employee Satisfaction and Motivation" +Ability to Attract New Employees +"G/M: Industry Reputation")/3	FA1
132	Required Blue Collar Employees = Yearly Total Newly Awarded Projects*"Ave. Number of Blue Collar Employee/ Project"	MA22
133	Hired Blue Collar Employees = Required Blue Collar Employees	MA22, FA2

134	Number of Blue Collar Employees(t) = Number of Blue Collar Employees(t - dt) + (Hired Blue Collar Employees - Blue Collar Employee Exists) * dt	MA22
135	Blue Collar Employee Exists = IF (Number of Blue Collar Employees>Min Number of Blue Collar Employee) THEN (Yearly Project Completion*"Ave. Number of Blue Collar Employee/ Project") ELSE 0	MA22
136	Number of High Skilled Employees(t) = Number of High Skilled Employees(t - dt) + (Hired High Skilled Employees - High Skilled Employee Exists) * dt	MA22
137	Hired High Skilled Employees = 0,1*Hired White Collar Employees*((50+("Reputation (for other stakeholders)"*10))/100)	MA22, FA2
138	High Skilled Employee Exists = ((Number of High Skilled Employees*(50+(Employee Turnover*10))/100)/"Ave. Actual Project Duration") + (IF Number of White Collar Employees<=20 THEN (Number of High Skilled Employees*White Collar Employee Exists/Number of White Collar Employees) ELSE 0)	MA22, FA2
139	"% High Skilled Employees" = IF (Number of White Collar Employees>=1 AND Number of High Skilled Employees>=1) THEN (Number of High Skilled Employees/Number of White Collar Employees)*100 ELSE 0	MA22
140	Required White Collar Employees = IF ((Yearly Total Newly Awarded Projects*Year Conversion)>Total Ongoing Projects) THEN ((Yearly Total Newly Awarded Projects*"Ave. Number of White Collar Employee/Project")-(Number of White Collar Employees/Year Conversion)) ELSE 0	MA22
141	Hired White Collar Employees = Required White Collar Employees* ((50+("G/M: Availability of Skilled Employee" +"G/M: Industry Reputation" +Ability to Attract New Employees)/3*10)/100)	MA22, FA2
142	Number of White Collar Employees(t) = Number of White Collar Employees(t - dt) + (Hired White Collar Employees - White Collar Employee Exists) * dt	MA22
143	White Collar Employee Exists = ((Number of White Collar Employees*(50+(Employee Turnover*10))/100)/"Ave. Actual Project Duration") + (IF ((Yearly Total Newly Awarded Projects*Year Conversion)>Total Ongoing Projects) THEN 0 ELSE ((Number of White Collar Employees/Year Conversion)- (Yearly Project Completion*"Ave. Number of White Collar Employee/Project")))	MA22, FA2
144	Total Number of Employee Exists = Blue Collar Employee Exists +White Collar Employee Exists +High Skilled Employee Exists	
145	Total Number of Employee Hires = Hired White Collar Employees +Hired Blue Collar Employees +Hired High Skilled Employees	
146	Total Number of Employees = Number of Blue Collar Employees +Number of White Collar Employees	
147	Total Annual Salary of High Skilled Employees = Number of High Skilled Employees*"Ave. Annual Salary Provided to High Skilled Employees"	
148	Total Annual Salary of Other White Collar Employees = "Ave. Annual Salary Provided to Other White Collar Employees"*(Number of White Collar Employees-Number of High Skilled Employees)	

149	Total Annual Salary of White Collar Employees = Total Annual Salary of Other White Collar Employees +Total Annual Salary of High Skilled Employees	
150	Human Capital Capability(t) = Human Capital Capability(t - dt) + (Yearly Imp of Human Capital - Disposal of Human Capital) * dt	
151	Yearly Imp of Human Capital = IF (Human Capital Capability+("R/C: Employee Training" +"R/C: Maturity of HR Applications" +Knowledge & Intellectual Capability)/3>=0) AND (Human Capital Capability+("R/C: Employee Training" +"R/C: Maturity of HR Applications" +Knowledge & Intellectual Capability)/3<=5) THEN ("R/C: Employee Training" +"R/C: Maturity of HR Applications" +Knowledge & Intellectual Capability)/3/"Ave. Actual Project Duration" ELSE 0	DC1
152	Disposal of Human Capital = IF (Human Capital Capability>=5) THEN 0 ELSE (IF(Human Capital Capability<=-5) THEN 0 ELSE (Human Capital Capability*((50+(("G/M: Advances in HR Applications" +Employee Turnover)/2)*10))/100)/"Ave. Actual Project Duration")	DC1
153	Human Capital Expenses = IF(Yearly Imp of Human Capital>0) THEN (Yearly Imp of Human Capital*Improvement Cost) ELSE 0	DC1
154	Technology & Innovation Capability (t) = Technology & Innovation Capability (t - dt) + ("Yearly Imp. of Technology & Innovation Capability" - Disposal of Technology Capital) * dt	DC1
155	"Yearly Imp. of Technology & Innovation Capability" = IF (Technology & Innovation Capability<=-5) THEN 0 ELSE (IF(Technology & Innovation Capability+ ("R/C: Maturity in Automation and Digitization" +"R/C: Maturity of IT Applications “+Technology & Innovation Capability +Human Capital Capability)/4<=5) THEN ("R/C: Maturity in Automation and Digitization" +"R/C: Maturity of IT Applications" +Technology & Innovation Capability +Human Capital Capability)/4/"Ave. Actual Project Duration" ELSE (5-Technology & Innovation Capability)/"Ave. Actual Project Duration")	DC1
156	Disposal of Technology Capital = IF (Technology & Innovation Capability>=5) THEN 0 ELSE (IF(Technology & Innovation Capability<=-5) THEN 0 ELSE (Technology & Innovation Capability*((50+(("G/M: Advances in Technology" +Employee Turnover)/2)*10))/100)/"Ave. Actual Project Duration")	DC1
157	Technology & Innovation Expenses = IF("Yearly Imp. of Technology & Innovation Capability">0) THEN ("Yearly Imp. of Technology & Innovation Capability"*Improvement Cost) ELSE 0	DC1
158	Technology Integration Level = Total Ongoing Projects* (50+(Technology & Innovation Capability*10))/100	FA2
159	Innovation Spending = IF("G/M: Benefits Provided for Innovation">0) THEN Yearly Realized Budget*0,01 ELSE Yearly Realized Budget*0,03	MA23
160	Gains from Innovation = IF(Technology & Innovation Capability>0) THEN Innovation Spending* Technology & Innovation Capability ELSE 0	MA23

161	Targeted Innovation Initiatives = IF("G/M: Advances in Technology">=3) THEN 10 ELSE IF("G/M: Advances in Technology">0 AND "G/M: Advances in Technology"<3) THEN 8 ELSE 5	MA24
162	Implemented Innovation Initiatives = Targeted Innovation Initiatives*(50+(Technology & Innovation Capability*10))/100	MA24, FA2
163	Knowledge & Intellectual Capability (t) = Knowledge & Intellectual Capability (t - dt) + ("Yearly Imp. of Knowledge Capability" - Disposal of Knowledge Capital) * dt	DC1
164	"Yearly Imp. of Knowledge Capability" = IF (Knowledge & Intellectual Capability+("R/C: Organizational Effectiveness" +"R/C: Organizational Learning" +Human Capital Capability)/3>=0) AND (Knowledge & Intellectual Capability+("R/C: Organizational Effectiveness" +"R/C: Organizational Learning" +Human Capital Capability)/3<=5) THEN ("R/C: Organizational Effectiveness" +"R/C: Organizational Learning" +Human Capital Capability)/3/"Ave. Actual Project Duration" ELSE 0	DC1
165	Disposal of Knowledge Capital = IF (Knowledge & Intellectual Capability>=5) THEN 0 ELSE (IF(Knowledge & Intellectual Capability<=-5) THEN 0 ELSE (Knowledge & Intellectual Capability*((50+(("G/M: Advances in Organizational Studies" +Employee Turnover)/2)*10))/100)/"Ave. Actual Project Duration")	DC1
166	Knowledge Capital Expenses = IF("Yearly Imp. of Knowledge Capability">0) THEN ("Yearly Imp. of Knowledge Capability"*Improvement Cost) ELSE 0	DC1
167	"Number of Post-Project Appraisals" = Total Completed Projects*(50+(Knowledge & Intellectual Capability*10))/100	MA25, FA2

APPENDIX 9: MODEL MODIFICATIONS

Obs ID	Test ID	Test Type	Problems/ Observations	Solutions/ New Developments
1	Test 4	Dimensional Consistency Test	There is a dimensional inconsistency in employee hires and exists. It is observed that neither level of employee hires nor exists, do not change based on whether new projects are awarded, or existing projects are completed.	As employee hires and exists depend on project duration in realy life, "actual project duration" is added in order to reflect the time dimension.
2	Test 4	Dimensional Consistency Test	It is observed that, number of accidents does not depend on number of projects.	The dimension of number of accidents is changed from accidents to accidents/ projects, as well as "Ave. Number of Blue Collar Employee/ Project" is defined as an input parameter for it.
3	Test 4	Dimensional Consistency Test	There is a dimensional inconsistency in the parameter "total budget of newly awarded projects", as while its input parameters have USD/ Years unit, while it has unit of "USD"	The type of the "total budget of newly awarded projects" is changed from stock parameter to the flow parameter, its name is changed as "yearly total budget of newly awarded projects", and its unit is changed from USD to USD/years.
4	Test 4	Dimensional Consistency Test	RC and GM parameters have unit of "rating", as they represent qualitative input parameters to the KPIs. However, nearly all KPIs have units different from "rating", which eventually lead dimensional inconsistency in whole equations.	To ensure dimensional consistency, the units of “rating” of RC and GM parameters are converted into "dimensionless".
5	Test 4	Dimensional Consistency Test	Targeted budget of potential national/ international projects have unit of "rating*USD". This parameter is an input for the "Yearly Budget of Newly Awarded Projects" which has unit of USD/ Years. Another input for that parameter is the "Newly Awarded International Projects" which has unit of Projects/Years.	The dimension of "Targeted budget of potential national/ international projects" are changed from "Rating* USD" to "USD/ Projects.
6	Test 4	Dimensional Consistency Test	Newly awarded international/national projects have a unit of "projects", representing total number of projects in a single year.	The dimension of "newly awarded international/ national projects" is changed from "projects" to "projects/years".
7	Test 4	Dimensional Consistency Test	There is a general problem about dimension of yearly improvement costs of RC. The tool suggested "Rating*USD/ Years" but it is expected to have "USD/Year".	After the units of "rating" are converted to "dimensionless" this problem is also solved.

8	Test 4	Dimensional Consistency Test	There is a general problem about unit of disposal of RCs. As they are outflow parameters for stocks representing capabilities, they should have 1/year unit.	To add year dimension, "average project duration" is linked with disposal of capabilities. This also enabled to consider disposal of capabilities through project completions.
9	Test 5	Boundary-Adequacy Test	At the end of the Trial 1, it is understood that the most vulnerable parameter to the boundary adequacy is the "Total number of Employees", as it failed in boundary conditions in 18 runs.	The stock type of "Total Number of Employees" is checked and it is seen that "Total Number of blue collar employees" and "Total Number of white collar employees" are not selected as "non-negative" stock. Then their stock option changed to the non-negative stock as the employee number cannot be turned into negative value.
10	Test 5	Boundary-Adequacy Test	At the end of the Trial 1, it is understood that the second most vulnerable parameter to the boundary adequacy is the "Reputation for other stakeholders" and "Creditor- financial availability".	Then the computerized model and formulations of these parameters are reviewed and it is seen that any disposal parameter is not defined for them. Then, disposal parameters are added.
11	Test 5	Boundary-Adequacy Test	During Trial 1, it is observed that disposal rates, are in general, fail in boundary adequacy. After detailed examinations, it is understood that, this failure can be contributed to the assumption of formulating disposal rates as a fix percentage. For example if the GM is larger than zero then it is assumed the capability will dispose by %20 independent from its current value.	Then the fix percentage of 20% is assigned as a proportion of value of associated RC. Such that, if GM is larger than zero, then capability will dispose %20 of its current value.
12	Test 5	Boundary-Adequacy Test	Technology integration level has boundary adequacy errors in extreme cases. Conceptual model for technology integration level has changed. First it is linked with total newly awarded projects then it is changed to ongoing projects. **Previous Formula:** Technology Integration Level = Total Newly Awarded Projects* (50+(Technology & Innovation Capability*10))/100	Then, the formula of technology integration level is changed to the "ongoing projects". **New Formula:** Technology Integration Level = Total Ongoing Projects* (50+(Technology & Innovation Capability*10))/100
13	Test 5	Boundary-Adequacy Test	A boundary adequacy error is occurred in "Innovation Spending" and "Gains from Innovation". **Previous Formula:** Innovation Spending = IF("G/M: Benefits Provided for Innovation">0) THEN Total Budget of Newly Awarded Projects*0,01 ELSE Total Budget of Newly Awarded Projects*0,03	Conceptual model of "Innovation Spending" and "Gains from Innovation" are changed. First, their parameter type is changed from "flow" to a "converter". Then, their input parameter of "Yearly Revenue" is changed to the "Total Budget of Newly Awarded Projects". **New Formula:** Innovation Spending = IF("G/M: Benefits Provided for Innovation">0) THEN Yearly Realized Budget*0,01 ELSE Yearly Realized Budget*0,03

14	Test 5	Boundary-Adequacy Test	A boundary adequacy error is occurred in "Cost of poor health and safety". **Previous Formula:** Cost of Poor Health and Safety = ((Fatalities*"Ave. Fatality Cost")+(Number of Accidents*"Ave. Accident Cost"))*Total Number of Newly Awarded Projects	"Cost of poor health and safety" is firstly linked with "Total Newly Awarded Projects” then it is changed to "Ongoing Projects" to ensure boundary-adequacy and behavioral validity. **New Formula:** Cost of Poor Health and Safety = ((Number of Fatalities*"Ave. Fatality Cost")+(Number of Accidents*"Ave. Accident Cost"))*(Total Ongoing Projects/Year Conversion)
15	Test 5	Boundary-Adequacy Test	A boundary adequacy error is occurred in "Cost of Regulatory Issues". **Previous Formula:** Cost of Regulatory Issues = Total Revenue Growth*"Regulatory Issues/ Budget Ratio"*((50-(Regulatory Issues Mitigation Performance*10))/100)	"Cost of Regulatory Issues" is firstly linked with "Total Revenue" but then changed to "Yearly Total Budget of Newly Awarded Projects" to ensure boundary-adequacy and behavioral validity. **New Formula:** Cost of Regulatory Issues = Yearly Total Budget of Newly Awarded Projects*"Regulatory Issues/ Budget Ratio"*((50-(Regulatory Issues Mitigation Performance*10))/100)
16	Test 5	Boundary-Adequacy Test	A boundary adequacy error is occurred in "Ongoing Projects".	Allowable amount of ongoing projects are first linked to the "Targeted Projects". Then it is linked to "Newly Awarded Projects".
17	Test 5	Boundary-Adequacy Test	A boundary adequacy error is occurred in "Targeted Projects".	"Targeted Projects" are first formulated through "Ongoing Projects". Then it is linked to "Project Completion Rate".
18	Test 5	Boundary-Adequacy Test	A boundary adequacy error is occurred in "Total Budget of Newly Awarded Projects".	Parameter type of the "Total budget of newly awarded projects" is changed from "conveyor" to a "flow"
19	Test 5	Boundary-Adequacy Test	A boundary adequacy error is occurred in "Yearly Company Expenses".	Parameter type of the "Yearly Company Expenses" is changed from "conveyor" to a "flow".
20	Test 5	Boundary-Adequacy Test	A boundary adequacy error is occurred in yearly improvement rates.	Yearly improvement rate for risk management, contract management and regulatory compliance are changed.
21	Test 6	Behavior-Abnormally Test	It is observed that, although the technology capability is nearly 5, revenue gained from innovation is smaller than innovation spending. However, it should be larger. **Previous Formula:** Revenue From Innovation = Innovation Spending*(50+(Technology & Innovation Capability*10))/100	The formula of "Gains from Innovation" is changed. **New Formula:** Gains from Innovation = IF(Technology & Innovation Capability>0) THEN Innovation Spending* Technology & Innovation Capability ELSE 0

22	Test 6	Behavior-Abnormally Test	"Residual Risk Level" and "Residual Cost Level" have boundary adequacy errors in extreme cases. Their conceptual models are changed.	**New Formula:** Residual Cost Risk= IF(Risk Management Capability>=Complexity) THEN (Project Cost Overrun Risk Level-(((Risk Management Capability-Complexity)/10)*(Project Cost Overrun Risk Level-1))) ELSE Project Cost Overrun Risk Level
23	Test 6	Behavior-Abnormally Test	It is observed that cost variation is so high which does not reflect the reality. Thus formula for "Earned Budget for Work Performed" should be changed. **Previous Formula:** Total Earned Budget For Work Performed= IF(Residual Cost Overrun Risk>=1) THEN Total Realized Budget*((50+Cost Management Performance*10)/100)/Residual Cost Overrun Risk ELSE Total Realized Budget*((50+Cost Management Performance*10)/100)	The formula of "Earned Budget for Work Performed" is changed. **New Formula:** Total Earned Budget for Work Performed = IF Cost Management Performance>=3 THEN Total Realized Budget*((50+((Cost Management Performance)*10))/100) ELSE Total Realized Budget*((50+((Cost Management Performance/Residual Cost Overrun Risk)*10))/100)
24	Test 6	Behavior-Abnormally Test	It is observed that schedule variation is so high which does not reflect the reality. Thus formula for "Earned Duration for Work Performed" should be changed. **Previous Formula:** Total Earned Duration for Work Performed = IF(Residual Delay Risk>=1) THEN Total Realized Project Duration*((50+Time Management Performance*10)/100)/ Residual Delay Risk ELSE Total Realized Project Duration* ((50+Time Management Performance*10)/100)	The formula of "Earned Duration for Work Performed" is changed. **New Formula:** Total Earned Duration for Work Performed = IF Time Management Performance>=3 THEN Total Realized Project Duration*((50+((Time Management Performance)*10))/100) ELSE Total Realized Project Duration*(50+((Time Management Performance/Residual Delay Risk)*10))/100
25	Test 6	Behavior-Abnormally Test	Complexity should be a number between 0-1. However, after behavior test 3 it is observed that complexity is assumed a number between 1 and 5 in the formula of "Improvement Cost". **Previous Formula:** Improvement Cost = IF(Complexity>3) THEN "UnitCost for High Level Req. for Org. Competence" ELSE (IF(Complexity<3 AND Complexity>0) THEN "UnitCost for Medium Level Req. for Org. Competence" ELSE "Unit Cost for Low Level Req. for Org. Competence")	The formula of "Improvement Cost" is changed. **New Formula:** Improvement Cost = IF(Complexity>=0,7) THEN "UnitCost for HighLevel Req. for Org. Competence" ELSE (IF(Complexity<0,7 AND Complexity>=0,4) THEN "UnitCost for Medium Level Req. for Org. Competence" ELSE "Unit Cost for Low Level Req. for Org. Competence")
26	Test 6	Behavior-Abnormally Test	Although cost and time management performance increases through years and in the same time residual delay and cost overrun risk decreases, it is observed that, cost variation and time variation increases. However, in real life, they are expected to decrease.	Thus both the conceptual and computerized model of the parameters "cost management performance", "time management performance", "residual delay risk", "residual cost overrun risk" are changed.

27	Test 6	Behavior-Abnormally Test	In one of the trials, it is observed that "required blue collar employees" is smaller than "hired blue collar employees". However in real life, it is expected that hired number of employees is smaller than required blue collar employees"	Thus, the conceptual and computerized model of "required blue collar employees" and "hired blue collar employees" are changed.
28	Test 6	Behavior-Abnormally Test	In one of the trials, it is observed that, although competitiveness of the company is increasing and the market is attractive, the targeted and newly awarded projects are not high as expected.	Thus, the conceptual and computerized model of the "targeted number of potential projects" and "total number of newly awarded projects" are changed.
29	Test 6	Behavior-Abnormally Test	It is observed that, disposal formulas are wrong due to boundary limit of complexity in the disposal formula. As the complexity is always larger than 0, then it changed the "0" in the formula should be a number larger than 0. **Previous Formula:** Disposal of Risk Management Capability = IF (Risk Management Capability>=5) THEN 0 ELSE (IF(Risk Management Capability<=-5) THEN 0 ELSE (IF(Complexity>0) THEN Risk Management Capability*0,2/"Ave. Actual Project Duration" ELSE Risk Management Capability*0,1/"Ave. Actual Project Duration"))	The formula of "Complexity" in the formulas of Disposal of Risk Management Capability, Regulatory Compliance and Contract Management Capability are changed. **New Formula:** Disposal of Risk Management = IF (Risk Management Capability>=5) THEN 0 ELSE (IF(Risk Management Capability<=-5) THEN 0 ELSE Risk Management Capability*((50+(Complexity*10))/100)/"Ave. Actual Project Duration")
30	Test 6	Behavior-Abnormally Test	The formula for "total earned budget for work performed" is changed again due to behavior abnormally. **Previous Formula:** Total Earned Budget For Work Performed= Total Realized Budget*((50+(Cost Management Performance/Residual Cost Overrun Risk)*10)/100)	**New Formula:** Total Earned Budget for Work Performed = IF Cost Management Performance>=3 THEN Total Realized Budget*((50+((Cost Management Performance)*10))/100) ELSE Total Realized Budget*((50+((Cost Management Performance/Residual Cost Overrun Risk)*10))/100)
31	Test 6	Behavior-Abnormally Test	The formula for "Targeted Number of national/ international Projects" has changed due to behavior abnormally.	
32	Test 6	Behavior-Abnormally Test	-	It is decided to add Cost of Poor Health and Safety, Cost of Regulatory Issues, Innovation Spending and Total Annual Salary of White Collar Employees as expenses to the "General and Administrative Expenses"
33	Test 6	Behavior-Abnormally Test	-	It is decided to add "Gains from claims" and "Gains from innovation" as "Other Gains" as a separate stock/ flow diagram. **New Formula:** Yearly Other Operating Gains = Gains from Claims +Gains from Innovation

34	Test 6	Behavior-Abnormally Test	It is observed that "Other Gains" did not included in the "Total Shareholder Revenue".	Formula for "Total Shareholder Revenue" is changed.
35	Test 6	Behavior-Abnormally Test	It is observed that there is no need to link corporate financial strength to the hired blue collar employees. Previously, corporate financial strength determines in what extent the company can hire the required amount of personnel. **Previous Formula:** Hired Blue Collar Employees= Required Blue Collar Employees* (50+"R/C: Corporate Financial Strength"*10)/100)	But after discussions with company experts, it is evaluated that the company can hire exactly the same amount of required blue collar employee as their budget is included in the project budget as labor budget. **New Formula:** Hired Blue Collar Employees = Required Blue Collar Employees
36	Test 6	Behavior-Abnormally Test	Formula for tax paid is changed. It is observed that at initial time although revenue is 0 tax paid is 118 m$. **Previous Formula:** Tax Paid= Yearly Revenue Growth*VAT_%	Time condition is added to the formula of Tax Paid. **New Formula:** Tax Paid= IF (TIME>1) THEN (Yearly Revenue Growth*VAT_%) ELSE 0
37	Test 6	Behavior-Abnormally Test	It is observed that, if company does not have any ongoing projects, then its blue collar personnel equals to 0. However; for upcoming projects it still remains some of its blue collar employees in real life. **Previous Formula:** Blue Collar Employee Exists= IF (Number of Blue Collar Employees>0) THEN (Yearly Project Completion*"Ave. Number of Blue Collar Employee/ Project") ELSE 0	It is decided to maintain 1000 blue collar personnel at least. **New Formula:** Blue Collar Employee Exists= IF (Number of Blue Collar Employees>1000) THEN (Yearly Project Completion*"Ave. Number of Blue Collar Employee/ Project") ELSE 0
38	Test 6	Behavior-Abnormally Test	It is understood that initial numbers of white collar, blue collar and high skilled employees are embedded into the model. But they should be initial/input values that should be defined by company experts. Thus, their conceptual model is changed	Conceptual models of "number of white collar, blue collar and high skilled employees" are changed and its initial values are defined as an input parameter.
39	Test 6	Behavior-Abnormally Test	It is observed that, the results produced by the model for the parameter of "total number of employees" is wrong. **Previous Formula:** Total Number of Employees(t) = Total Number of Employees(t - dt) + (Hired Total Employees – Total Employee Exists) * dt	The conceptual model of "total number of employees" is changed from a stock parameter to a converter. **New Formula:** Total Number of Employees = Number of Blue Collar Employees+ Number of White Collar Employees

40	Test 6	Behavior-Abnormally Test	**Previous Formula:** White Collar Employee Exists = IF (Number of White Collar Employees>=0) THEN (IF(Total Number of Newly Awarded Projects<10) THEN (Number of White Collar Employees *(50+(Employee Turnover*10))/100)/"Ave. Actual Project Duration" ELSE (Yearly Project Completion*"Ave. Number of White Collar Employee/Project")) ELSE 0	**New Formula:** White Collar Employee Exists = ((Number of White Collar Employees*(50+(Employee Turnover*10))/100)/"Ave. Actual Project Duration") + (IF ((Yearly Total Newly Awarded Projects*Year Conversion)>Total Ongoing Projects) THEN 0 ELSE ((Number of White Collar Employees/Year Conversion)- (Yearly Project Completion*"Ave. Number of White Collar Employee/Project")))
41	Test 7	Boundary-Adequacy Test	When income is 0, then net profit and gross profit margin give "division by 0" error. **Previous Formula:** Net Profit Margin= IF (TIME>1) THEN "Net Profit/Loss"/Shareholder Revenue*100 ELSE 0 Gross Profit Margin= IF (TIME>1) THEN "Gross Profit/Loss"/Shareholder Revenue*100 ELSE 0	Thus, additional condition is added to the formula of net profit and gross profit margin. **New Formula:** Gross Profit Margin = IF (TIME >1) THEN (IF (Yearly Project Revenue>0) THEN (Yearly Gross Profit/Yearly Project Revenue)*100 ELSE 0) ELSE 0 Net Profit Margin = IF (TIME>1) THEN (IF (Yearly Shareholder Revenue>0) THEN (Yearly Net Profit/Yearly Shareholder Revenue)*100 ELSE 0) ELSE 0
42	Test 7	Boundary-Adequacy Test	**Previous Formula:** % High Talented Employees" = IF (Number of White Collar Employees>0) THEN (Number of High Skilled Employees/ Number of White Collar Employees)*100 ELSE 0	**New Formula:** %_High Skilled Employees = IF (Number of White Collar Employees>=1 AND Number of High Skilled Employees>=1) THEN (Number of_ High Skilled Employees/Number of White Collar Employees)*100 ELSE 0
43	Test 8	Extreme Conditions Test	When all input conditions are assumed to be as "extreme positive", it is observed that targeted number of projects for both national and international market is about 2-3 projects. However; in real life, they are expected to be larger when all conditions are extremely positive.	Thus, it is understood that there is a formula error in targeted number of projects. When the formula for "targeted number of projects" is changed and extreme positive values are assigned again, and then targeted number of projects achieved to "manageable number of projects", which is also expected same in real life.
44	Test 9	Boundary-Adequacy Test	When the formula of "targeted number of projects" is changed due to the error obtained in Extreme Conditions Test, and then the model is failed in Boundary- Adequacy Test. It is observed that, there is boundary errors occurred in parameters of "% High talented employees", "annual salary of other white collar", "required white collar employees" and "white collar employee exists".	It is understood that some boundary condition should be assigned to the "% High talented employees", "annual salary of other white collar", "required white collar employees" and "white collar employee exists". **New Formula:** Required White Collar Employees= IF (Total Number of Newly Awarded Projects>Total Ongoing Projects) THEN (Total Number of_Newly_Awarded_Projects*"Ave._Number_of_White_Collar

			Previous Formula: Required White Collar Employees = Total Number of Newly Awarded Projects*"Ave. Number of White Collar Employee/Project"	_Employee/Project")-Number_of_White_Collar_Employees ELSE 0
45	Test 10	Extreme Conditions Test	In case cost overrun risk is equal to 1, then risk-related contingency will have %2 as an output value. However; in real life if cost overun risk is too low (having rating 1), then risk-related contingency might be expected to be 0. **Previous Formula:** "Risk-Related Contingency" = Residual Cost Overrun Risk/50*100	Thus, formula for the risk-related contingency is changed. **New Formula:** "Risk-Related Contingency" = IF (Residual Cost Overrun Risk=1) THEN 0 ELSE (Residual Cost Overrun Risk/50*100)
46	Test 10	Extreme Conditions Test	Tax paid is formulated by using revenue growth. As VAT is equal to %18, and contract markup is %10, independent from the performance of the company, net profit value is calculated as negative, that is loss. Thus, the formula for tax paid is changed. Then tax paid is formulated with "total budget of newly awarded projects". However, the result is not changed. Then it is realized that, in real life VAT is paid from realized expenses. **Previous Formula**: **First trial:** Tax Paid = Yearly Revenue Growth*VAT % **Second trial:** Tax Paid= IF (TIME>1) THEN (Total Budget of Newly Awarded Projects*VAT_%) ELSE 0	Thus, it is decided to formulate VAT from yearly realized budget. In addition, it is decided that, VAT is not applied to all expense items in real life, for example it is applied for expenses recorded with invoices i.e. material/equipment procurement. Thus, it is assumed that expenses, for which VAT is applied, cover %60 of realized budget. **New Formula:** Tax Expenses = IF (TIME>1) THEN (Yearly Realized Budget*VAT_%*0,6) ELSE 0
47	Test 10	Extreme Conditions Test	Yearly project expenses are formulated by cost management performance. **Previous Formula:** Yearly Operating Expenses= (Total Budget of Newly Awarded Projects)*((50+(Cost Management Performance*10))/100)	However, it is realized that, project expenses is actually the sum of awarded budget plus cost variation. **New Formula:** Yearly Operating Expenses= Total Budget of Newly Awarded Projects+ (IF (TIME >1) THEN Total Cost Variation/Total Realized Project Duration ELSE 0)
48	Test 10	Extreme Conditions Test	In extreme positive case, the targeted number of projects reaches manageable number of projects in the first year. In this case, first year the company will award 25/30 projects, but as it reaches the manageable number of projects, in second year the company could not award any projects. The excessive changes in the newly awarded projects lead to unrealistic changes in number of employees (such that, in second year nearly all employees will	Thus, it is assumed that, in case the company can target and win tenders in the manageable amount of project, in order to maintain at the safe side and increase its experience, they can target projects that are twice the number of completed projects, only at the first year.

			exit) and financial indicators (such that, in first year net profit is nearly 1 billion dollar but at second year it is zero).	
49	Test 10	Extreme Conditions Test	**Previous Formula:** Innovation Spending= IF("G/M: Benefits Provided for Innovation">0) THEN Total Budget of Newly Awarded Projects*0,01 ELSE Total Budget of Newly Awarded Projects*0,03	Innovation spending is formulated by using yearly-realized budget rather than total budget of newly awarded projects. **New Formula:** Innovation Spending= IF("G/M: Benefits Provided for Innovation">0) THEN Yearly Realized Budget*0,01 ELSE Yearly Realized Budget*0,03
50	Test 10	Extreme Conditions Test	**Previous Formula:** Revenue from Claims = Total Budget of Newly Awarded Projects*"Claim/_Budget Ratio"* ((50 +(Claim Mitigation Performance*10))/100)	Revenue from claims is formulated by using yearly realized budget rather than total budget of newly awarded projects. **New Formula:** Gains from Claims =Yearly Realized Budget*"Claim/ Budget Ratio"*((50+(Claim Mitigation Performance*10))/100)
51	Test 10	Extreme Conditions Test	In extreme negative test, % high- talented employees and annual salary of other white-collar employee had boundary adequacy error. **Previous Formula: H**igh Skilled Employee Exists= IF (Number of High Skilled Employees>0) THEN ((Number of High Skilled Employees* (50-(Employee Turnover*10))/100) /"Ave. Actual Project Duration" ELSE 0	The formula for "high skilled employee exists" is changed. **New Formula:** High Skilled Employee Exists = ((Number of High Skilled Employees*(50+(Employee Turnover*10))/100)/"Ave. Actual Project Duration") + (IF Number of White Collar Employees<=20 THEN (Number_of_High_Skilled_Employees*White_Collar_Employee _Exists/Number of White Collar Employees) ELSE 0)
52	Test 11	Dimensional Consistency Test	After some computational modifications made to comply with the Extreme Conditions Tests, it is observed that there are now some dimensional inconsistencies (7 unit warnings in total) occurred due to modifications. For example, after dimensional test, a year conversion parameter is added to the "newly awarded national/ international projects", "required white collar employees" etc.	**New Formula:** Required White Collar Employees = IF ((Yearly_Total_Newly_Awarded_Projects*Year_Conversion)>Total_Ongoing_Projects) THEN ((Yearly Total Newly Awarded Projects*"Ave. Number of White Collar Employee/Project")-(Number of White Collar Employees/Year Conversion)) ELSE 0
53	Test 11	Dimensional Consistency Test	Year conversion parameter is also added to the complexity parameter, as any dimensional inconsistency in complexity lead to inconsistency in residual delay/ cost overrun risk. **Previous Formula:** Complexity = (Total Ongoing Projects/ (Manageable Max Number of National Projects+ Manageable Max Number of International Projects))*5	**New Formula:** Complexity = ((Total Ongoing Projects/ (Manageable_Max_Number_of_National_Projects+Manageable _Max_Number of International Projects))*5)/Year Conversion

54	Test 11	Dimensional Consistency Test	It is observed that, the formula of "yearly project expenses" having unit of "USD/Years", includes the parameter of "total cost variation" which has units of USD. It is also conceptual error as "total cost variation" is a cumulative value rather than yearly variation.	Thus, the parameter of "total realized project durations", having unit of "Years" is added to the "total cost variation" formula in order to ensure conceptual reliability as well as dimensional consistency.
55	Test 11	Face Validity & Baseline Test	**Previous Formula: T**argeted Reduction in Energy and Water Consumption = IF(GM: Strictness of Environmental Regulations>2) THEN 0,2 ELSE IF(GM: Strictness of Environmental Regulations<=2 AND GM: Strictness of Environmental_ Regulations>0) THEN 0,1 ELSE 0,05	**New Formula:** Targeted Reduction in Energy and Water Consumption = 30*(50+(GM: Strictness of Environmental Regulations*10))/100
56	Test 15	Face Validity & Baseline Test	It is understood that, both the revenue and expenses of existing projects at time 0 are not included in the associated formulas. **Previous Formula:** Yearly Operating Expenses= Total Budget of Newly Awarded Projects+ (IF (TIME >1) THEN Total Cost Variation/Total Realized Project Duration ELSE 0)	Then, both the revenue and expenses of the initial projects are added to the formulas. **New Formula:** Yearly Project Expenses = Total Budget of Initial Projects+ (Yearly Total Budget of Newly Awarded Projects)+ (IF (TIME >1) THEN Total Cost Variation/Total Realized Project Duration ELSE 0)
57	Test 15	Face Validity & Baseline Test	It is decided that improvement cost is low while compared with current conditions. They changed input values accordingly. **Previous Inputs:** UnitCost for Medium Level Req. for Org. Competence= $ 50k , UnitCost for High Level Req. for Org. Competence= $ 100k, Unit Cost for Low Level Req. for Org. Competence= $ 10k	**New Inputs:** UnitCost for Medium Level Req. for Org. Competence= $ 100k, UnitCost for High Level Req. for Org. Competence= $ 250k, Unit Cost for Low Level Req. for Org. Competence= $ 50k
58	Test 15	Face Validity & Baseline Test	It is decided to define min number of blue collar employees as a input parameter, that is expected to be defined by the company experts. **Previous Formula:** Blue Collar Employee Exists= IF (Number of Blue Collar Employees>1000) THEN (Yearly Project Completion*"Ave. Number of Blue Collar Employee/ Project") ELSE 0	**New Formula:** Blue Collar Employee Exists = IF (Number of Blue Collar Employees>Min Number of Blue Collar Employee) THEN (Yearly Project Completion*"Ave. Number of Blue Collar Employee/Project") ELSE 0
59	Test 15	Face Validity & Baseline Test	**Previous Formula:** Targeted Number of National Projects= IF Attractiveness of National Construction Market>=0 AND Attractiveness of International Construction Market>=0 THEN (IF(Attractiveness of National Construction Market-Attractiveness of International Construction Market>=0) THEN	**New Formula:** Targeted Number of National Projects = IF Attractiveness of National Construction Market>=0 AND Attractiveness of International Construction Market>=0 THEN (IF(Attractiveness of National Construction Market-Attractiveness of International Construction Market>=0) THEN

			(Manageable Max Number of National Projects –Ongoing National Projects)/Yearly Project Duration Passed ELSE National Projects Completion Rate) ELSE National Projects Completion Rate*0,8	(IF TIME>1 THEN (Manageable Max Number of National Projects -National_ Projects Completion Rate)*0,7 ELSE National Projects Completion Rate*2) ELSE National Projects Completion Rate) ELSE National Projects Completion Rate*0,8
60	Test 15	Face Validity & Baseline Test	Targeted budget of newly awarded projects is a parameters expected to be defined by the decision makers. However; in order to enhance the support for the decision making process, company experts claimed that, targeted budget of potential projects should be a parameter automatically quantified by the tool based on the existing budget of the initial projects. Another limitation of defining targeted budget as a input parameter by the decision makers is that, it ignores changes in internal and external conditions by setting targeted budget as a fix value.	Formula of the targeted budget of potential projects is changed and it is converted from an input parameter to an output parameter. It is quantified by initial budget of projects, competitive advantage and market attractiveness. With the formula change, now targeted budget will be automatically quantified, support decision-making process as well as consider and reflects changes in internal and external conditions. In other words, rather than remaining as a fix value throughout the years, targeted budget will change year by year based on the changing conditions.
61	Test 15	Face Validity & Baseline Test	Contract profit margin is a parameters expected to be defined by the decision makers. However; in order to enhance the support for the decision making process, company experts claimed that, contract profit margin should be a parameter automatically quantified by the tool based on attractiveness of the market. Another limitation is that, contract markup is quantified by contract profit margin and risk-related contingency, in which only internal conditions are considered. Such that; risk-related contingency is quantified by residual cost overrun risk and complexity which are all affected by the internal conditions of the company. However, external conditions should also be considered when quantifying contract markup.	Formula of the contract profit margin is changed and its converted from an input parameter to an output parameter. It is quantified by min and max limit for the contract profit margin and market attractiveness. Thus, by changing the formula of contract profit margin through adding market attractiveness to its formula, external conditions are also considered in contract markup. In other words, if market attractiveness is high enough, company may foster higher contract profit margins.
62	Test 15	Face Validity & Baseline Test	Newly awarded projects are quantified by targeted number of projects, competitive advantage and strength of the competitors. Company experts claimed that, in the formula of newly awarded projects, it effect of contract markup on the ability to win new projects is ignored. For example, they claimed that, if contract markup is too high, company may not win any new projects even when its competitive advantage is high and strength of its competitors is low.	A new parameter, named RC: Ability to Make Lowest Bid, is added to the model. Ability to make lowest bid is calculated by the comparison of the contract markup of the company and market average markup. If company can lower its contract markup compared with market average, then it is assumed that it can increase its ability to make lowest bid. In accordance, the formula of Newly Awarded Projects is also changed.

63	Test 15	Face Validity & Baseline Test	Company experts claimed that, tendering performance of the company should also be quantified by the tool.	A new parameter, named Tendering Performance, is added to the model. **New Formula:** Tendering Performance = Yearly Total Newly Awarded Projects/Yearly Total Targeted Projects*100
64		Face Validity & Baseline Test	Company experts claimed that, cost overrun of the company should also be quantified by the tool.	A new formula, named Cost Overrun, is added to the model. **New Formula:** "Cost Overrun (%)" = IF (Total Cost Variation>0) THEN (IF (TIME>1) THEN Total Cost Variation/Total Realized Budget*100 ELSE 0) ELSE 0

APPENDIX 10: MODEL INTERFACES

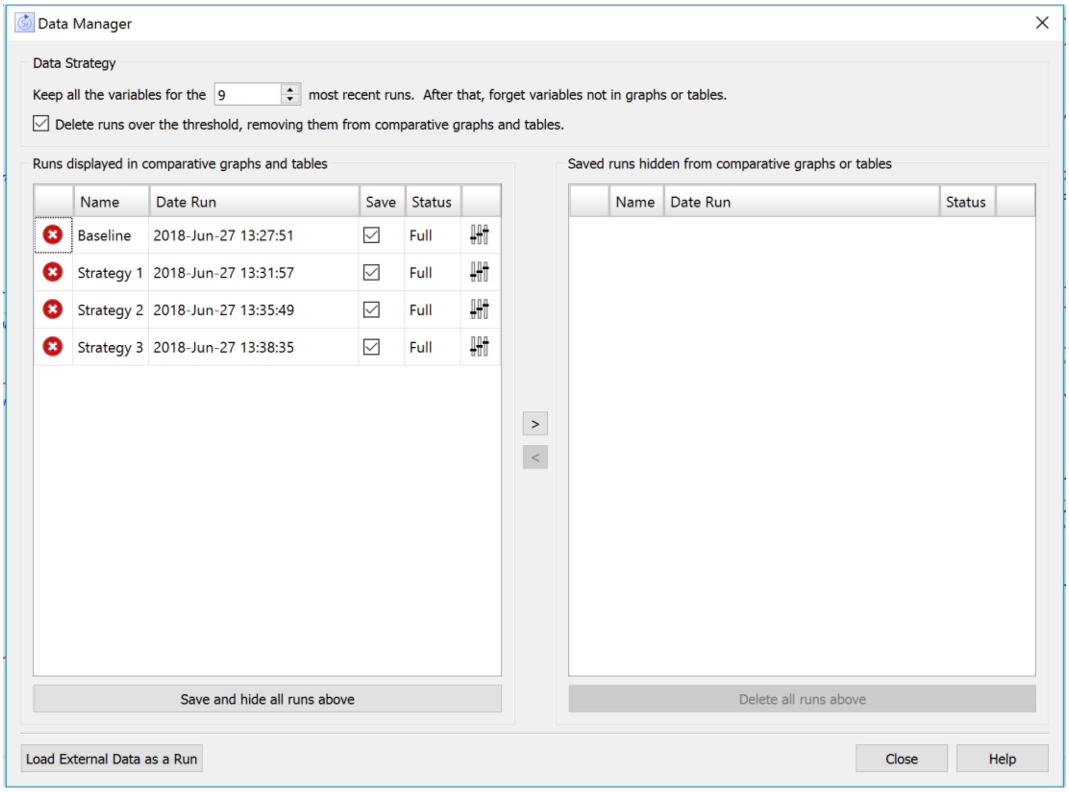


Figure 28: Data Manager of Stella Architecture

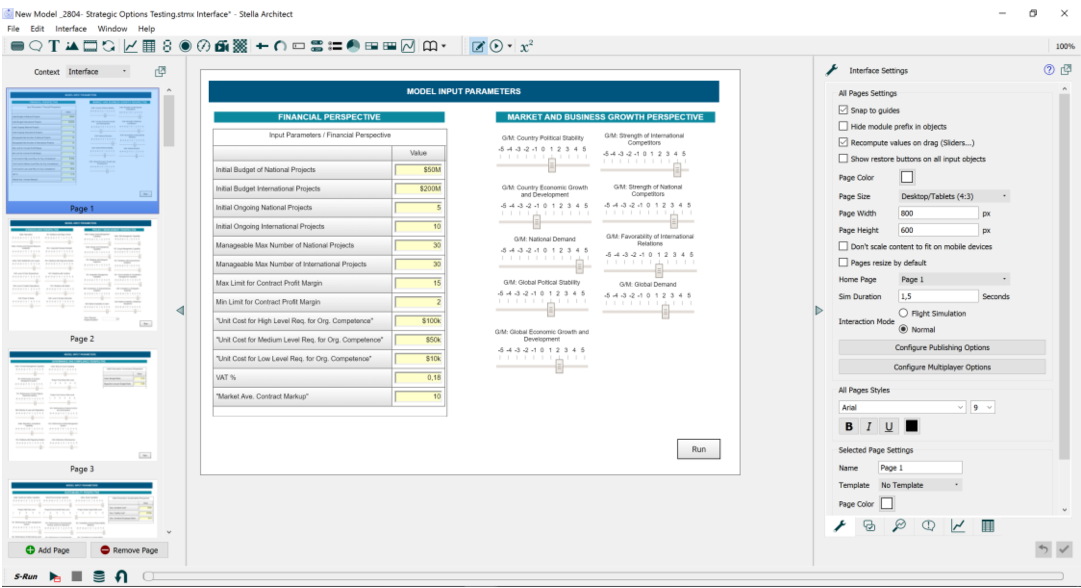


Figure 29: Interface Module of Stella Architecture

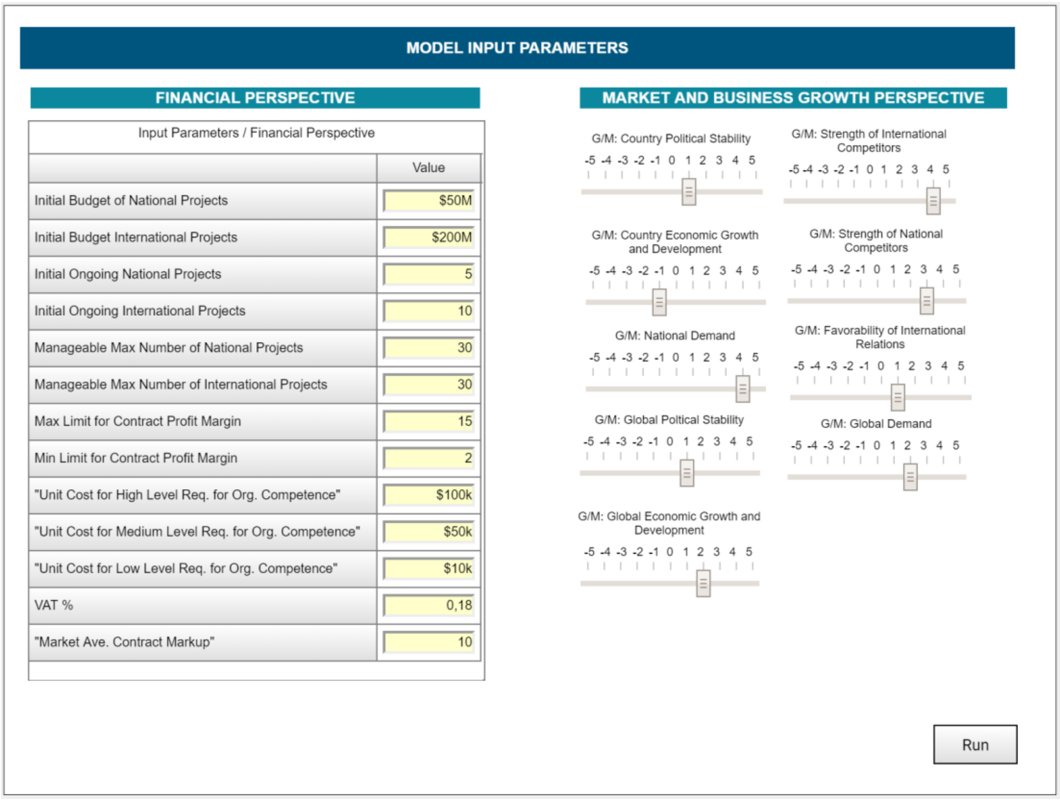


Figure 30: Data Entry Interface / Financial & Market and Business Growth Perspective

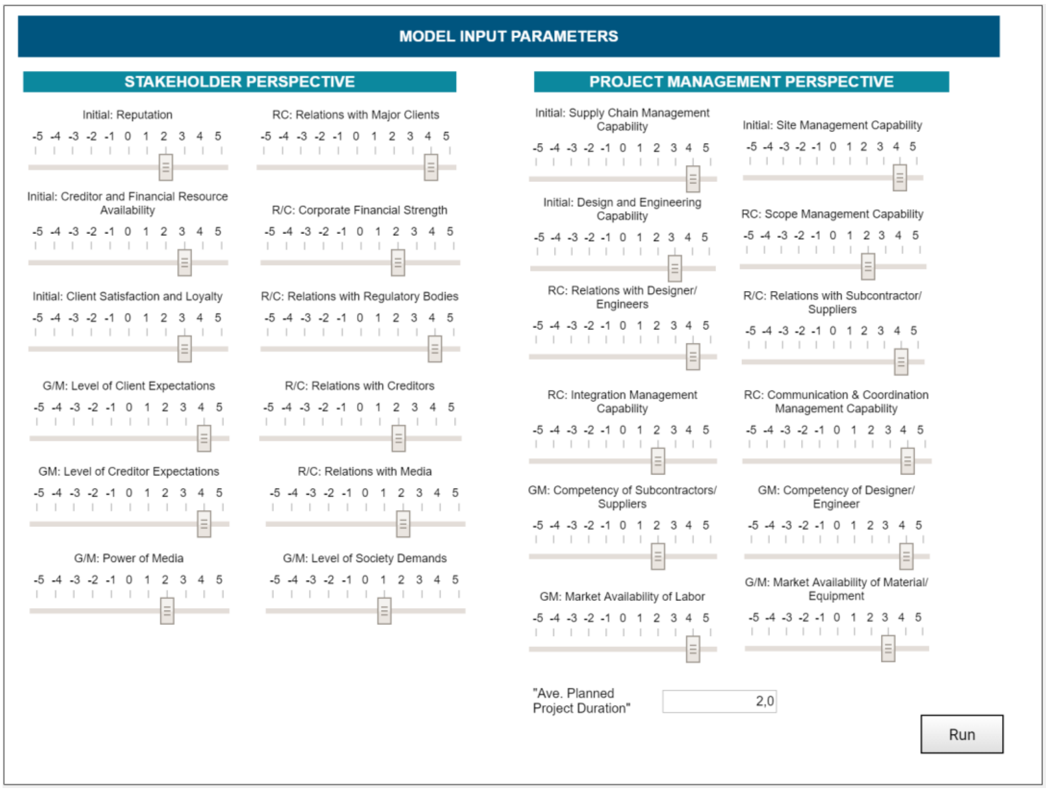


Figure 31: Data Entry Interface / Stakeholder Perspective & Project Management Perspective

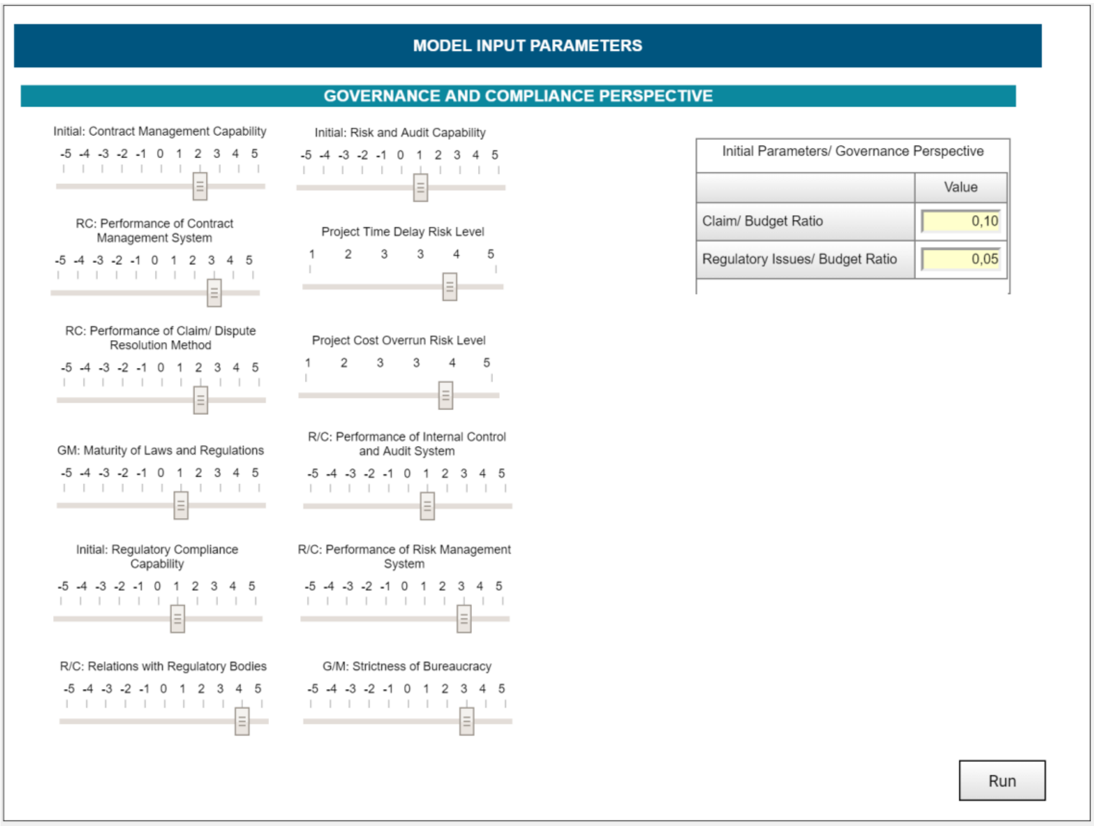


Figure 32: Data Entry Interface / Governance and Compliance Perspective

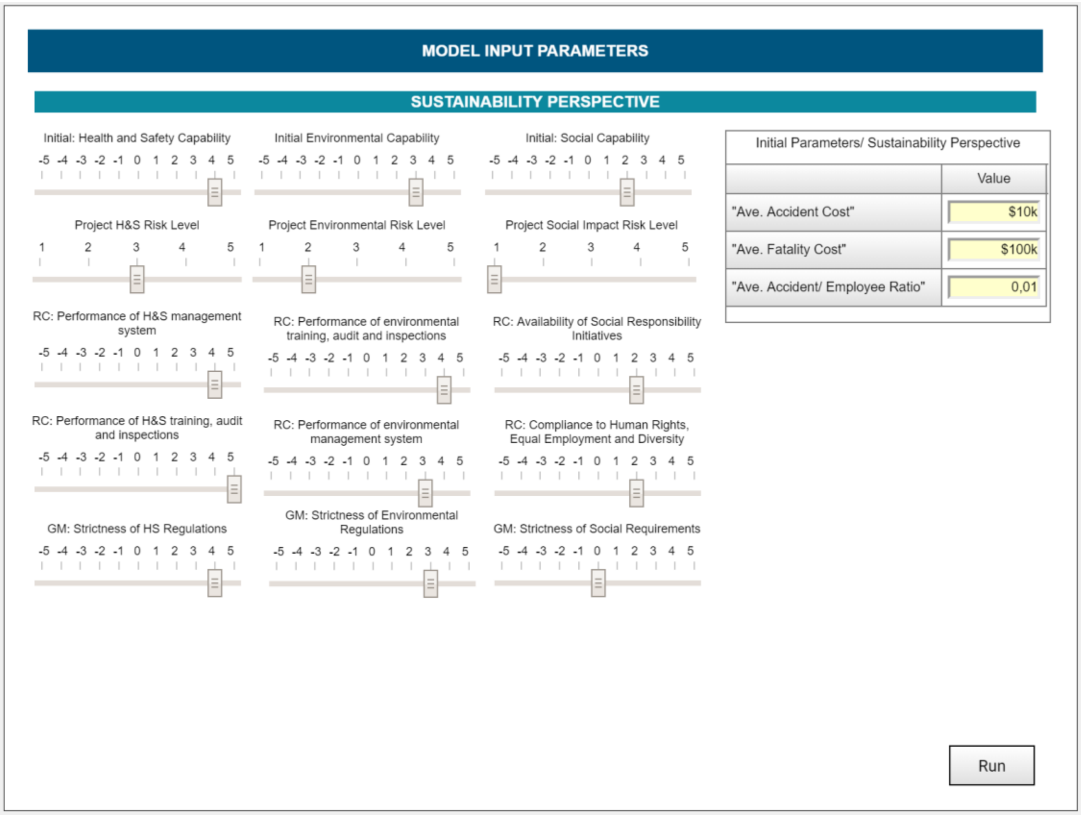


Figure 33: Data Entry Interface / Sustainability Perspective

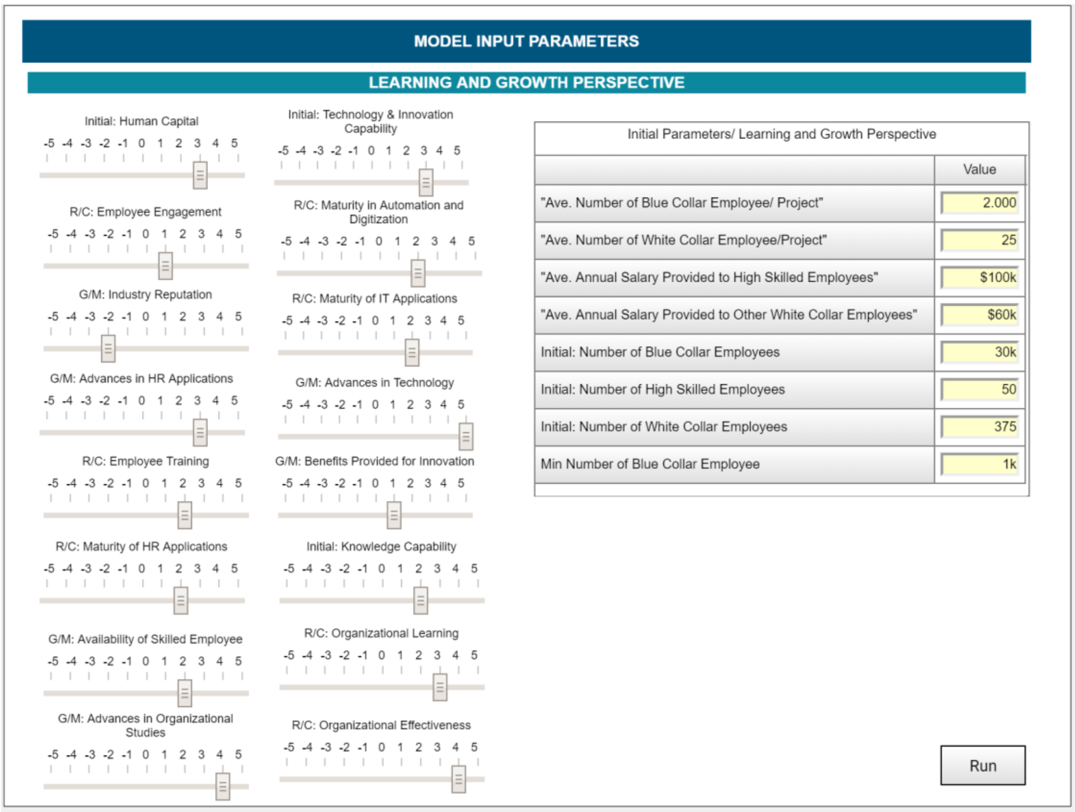
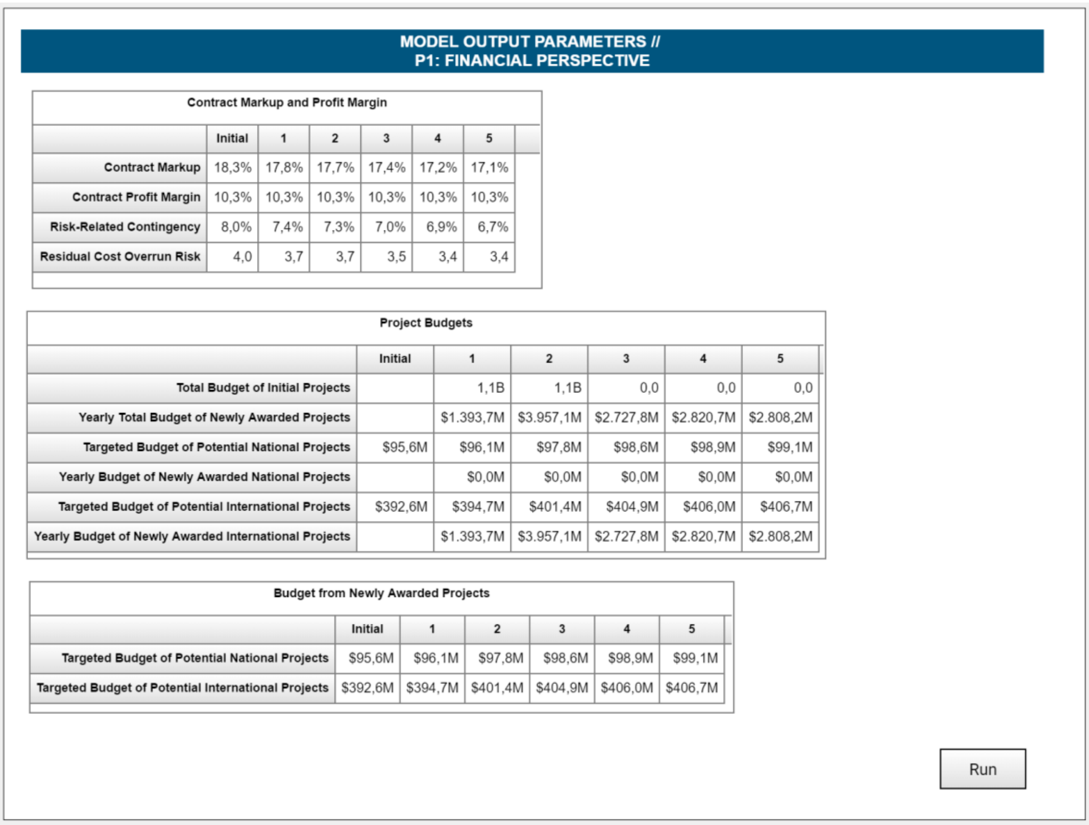


Figure 34: Data Entry Interface / Learning and Growth Perspective



MODEL OUTPUT PARAMETERS // P1: FINANCIAL PERSPECTIVE

Contract Markup and Profit Margin

	Initial	1	2	3	4	5
Contract Markup	18,3%	17,8%	17,7%	17,4%	17,2%	17,1%
Contract Profit Margin	10,3%	10,3%	10,3%	10,3%	10,3%	10,3%
Risk-Related Contingency	8,0%	7,4%	7,3%	7,0%	6,9%	6,7%
Residual Cost Overrun Risk	4,0	3,7	3,7	3,5	3,4	3,4

Project Budgets

	Initial	1	2	3	4	5
Total Budget of Initial Projects		1,1B	1,1B	0,0	0,0	0,0
Yearly Total Budget of Newly Awarded Projects		$1.393,7M	$3.957,1M	$2.727,8M	$2.820,7M	$2.808,2M
Targeted Budget of Potential National Projects	$95,6M	$96,1M	$97,8M	$98,6M	$98,9M	$99,1M
Yearly Budget of Newly Awarded National Projects		$0,0M	$0,0M	$0,0M	$0,0M	$0,0M
Targeted Budget of Potential International Projects	$392,6M	$394,7M	$401,4M	$404,9M	$406,0M	$406,7M
Yearly Budget of Newly Awarded International Projects		$1.393,7M	$3.957,1M	$2.727,8M	$2.820,7M	$2.808,2M

Budget from Newly Awarded Projects

	Initial	1	2	3	4	5
Targeted Budget of Potential National Projects	$95,6M	$96,1M	$97,8M	$98,6M	$98,9M	$99,1M
Targeted Budget of Potential International Projects	$392,6M	$394,7M	$401,4M	$404,9M	$406,0M	$406,7M

Run

Figure 35: Results Interface / Financial Perspective-1

MODEL OUTPUT PARAMETERS //
P1: FINANCIAL PERSPECTIVE

Revenues

	Initial	1	2	3	4	5
Total Shareholder Revenue	$0,0M	$3.096,0M	$9.167,3M	$12.647,0M	$16.236,3M	$19.815,1M
Yearly Shareholder Revenue		$3.096,0M	$6.071,3M	$3.479,7M	$3.589,3M	$3.578,8M
Total Project Revenue	$0,0M	$2.980,7M	$8.922,5M	$12.131,9M	$15.442,7M	$18.734,5M
Yearly Project Revenue		$2.980,7M	$5.941,8M	$3.209,4M	$3.310,8M	$3.291,8M
Other Operating Gains	$0,0M	$115,3M	$244,8M	$515,1M	$793,6M	$1.080,6M
Yearly Other Operating Gains		$115,3M	$129,5M	$270,3M	$278,5M	$287,0M

Expenses

	Initial	1	2	3	4	5
Total Company Expenses	$0,0M	$2.561,0M	$8.013,6M	$11.262,6M	$14.685,6M	$18.112,1M
Yearly Company Expenses		$2.561,0M	$5.452,7M	$3.248,9M	$3.423,0M	$3.426,5M
Total Project Expenses	$0,0M	$2.518,7M	$7.741,0M	$10.626,4M	$13.677,5M	$16.723,7M
Yearly Project Expenses		$2.518,7M	$5.222,3M	$2.885,4M	$3.051,1M	$3.046,1M
Total General & Administrative Expenses	$0,0M	$42,2M	$136,6M	$218,5M	$302,2M	$386,2M
Yearly G&A Expenses		$42,2M	$94,4M	$81,9M	$83,7M	$84,0M
Tax Expenses	$0,0M	$136,0M	$281,7M	$288,1M	$296,4M	$299,8M

Run

Figure 36: Results Interface / Financial Perspective-2

MODEL OUTPUT PARAMETERS //
P1: FINANCIAL PERSPECTIVE

Profit Margin

	Initial	1	2	3	4	5
Yearly Gross Profit		$462,0M	$719,5M	$324,1M	$259,6M	$245,6M
Total Gross Profit	$0,0M	$462,0M	$1.181,5M	$1.505,6M	$1.765,2M	$2.010,8M
Gross Profit Margin	0	12	10	8	7	7
Yearly Net Profit		$535,1M	$618,6M	$230,8M	$166,3M	$152,3M
Total Net Profit	$0,0M	$535,1M	$1.153,7M	$1.384,5M	$1.550,7M	$1.703,0M
Net Profit Margin	0	10	7	5	4	4

Improvement Unit Cost

	Initial	1	2	3	4	5
Improvement Cost	$100k	$100k	$100k	$100k	$100k	$100k
Complexity	1,3	0,9	1,3	1,2	1,2	1,2

General Administrative Expenses

	Initial	1	2	3	4	5
Total General & Administrative Expenses	$0,0M	$42,2M	$136,6M	$218,5M	$302,2M	$386,2M
Yearly G&A Expenses		$42,2M	$94,4M	$81,9M	$83,7M	$84,0M
Risk and Audit Expenses	$121k	$110k	$115k	$110k	$116k	$83k
Health and Safety Expensses	$50k	$111k	$114k	$115k	$116k	$117k
Social Expenses	$100k	$102k	$101k	$87k	$83k	$83k
Contract Expenses	$106k	$102k	$107k	$102k	$108k	$106k
Knowledge Capital Expenses	$0k	$162k	$0k	$147k	$0k	$159k
Regulatory Compliance Expenses	$133k	$133k	$114k	$104k	$103k	$103k
Technology & Innovation Expenses	$100k	$102k	$103k	$104k	$105k	$105k
Human Capital Expenses	$100k	$86k	$0k	$92k	$107k	$94k
Environmental Expenses	$100k	$106k	$107k	$108k	$109k	$110k
Cost of Poor Health and Safety	$0,9M	$1,5M	$2,2M	$2,1M	$2,1M	$2,0M
Cost of Regulatory Issues	$29,3M	$79,2M	$52,8M	$54,0M	$53,6M	$53,9M
Innovation Spending	$11,3M	$12,6M	$26,1M	$26,7M	$27,4M	$27,8M

Figure 37: Results Interface / Financial Perspective-3

MODEL OUTPUT PARAMETERS //
P2: MARKET AND BUSINESS GROWTH PERSPECTIVE

Project Portfolio

	Initial	1	2	3	4	5
Yearly Total Targeted Projects	13	19	17	16	16	16
Yearly Total Newly Awarded Projects	4	10	7	7	7	7
Total Completed Projects	0	8	13	20	28	35
Yearly Project Completion	8	5	8	7	7	7
Total Ongoing Projects	15	11	16	15	15	14

Tendering Performance

	Initial	1	2	3	4	5
Tendering Performance	28,4%	51,9%	40,6%	42,3%	42,5%	42,9%
Attractiveness of International Construction Market	1,5	1,5	1,5	1,5	1,5	1,5
Attractiveness of National Construction Market	1,3	1,3	1,3	1,3	1,3	1,3
R/C: Competitive Advantage	2,5	2,6	2,7	2,8	2,8	2,8
R/C: Ability to Make Lowest Bid	1,0	1,0	1,0	1,0	1,0	1,0

International Projects

	Initial	1	2	3	4	5
Targeted Number of International Projects	10	18	16	16	16	16
Newly Awarded International Projects		4	10	7	7	7
Ongoing International Projects	10	9	14	14	14	14
International Projects Completion Rate		5,0	4,1	7,0	6,9	7,0
Completed International Projects	0	5	9	16	23	30

National Projects

	Initial	1	2	3	4	5
Targeted Number of National Projects	3	1	1	0	0	0
Newly Awarded National Projects		0	0	0	0	0
Ongoing National Projects	5	3	1	1	0	0
National Projects Completion Rate		2,5	1,2	0,6	0,3	0,2
Completed National Projects	0	3	4	4	5	5

Run

Figure 38: Results Interface / Market and Business Growth Perspective

MODEL OUTPUT PARAMETERS //
P3: STAKEHOLDER PERSPECTIVE

Client Satisfaction and Loyalty

	Initial	1	2	3	4	5
Client Satisfaction and Loyalty	3,0	2,6	2,6	2,6	2,6	2,6
Client Retention Rate	1,0	1,2	1,2	1,2	1,2	1,2
Reputation (for other stakeholders)	2,0	2,7	3,0	3,0	3,0	3,0
Creditor and Financial Resource Availability	3,0	2,6	2,6	2,6	2,6	2,6

Key Capabilities

	Initial	1	2	3	4	5
RC: Learning and Growth Capability	2,7	2,4	2,8	2,2	2,6	2,4
RC: Sustainability Capability	3,0	2,7	2,8	2,9	2,9	2,9
RC: Governance and Compliance Capability	1,3	2,1	2,5	2,8	2,9	3,0
RC: Compliance to International Laws and Regulations	2,2	2,4	2,7	2,9	2,9	3,0
R/C: Competitive Advantage	2,5	2,6	2,7	2,8	2,8	2,8

Run

Figure 39: Results Interface / Stakeholder Perspective

MODEL OUTPUT PARAMETERS //
P4: PROJECT MANAGEMENT PERSPECTIVE

Supply Chain Management Performance

	Initial	1	2	3	4	5
Supply Chain Management Capability	4,0	4,5	4,7	4,9	4,9	5,0
Productivity of Machinery/Equipment	3,0	3,2	3,2	3,3	3,3	3,3

Design and Engineering Management Performance

	Initial	1	2	3	4	5
Technical Capabilities	3,0	4,0	4,5	4,7	4,9	4,9
Performance of Design& Engineering	3,5	4,0	4,2	4,4	4,4	4,5

Site Management Performance

	Initial	1	2	3	4	5
Site Management Capability	4,0	4,5	4,7	4,9	4,9	5,0
Labor Productivity	3,3	3,5	3,6	3,6	3,6	3,7

Project Management Performance

	Initial	1	2	3	4	5
Cost Management Performance	3,2	3,4	3,7	3,6	3,8	3,7
Time Management Performance	3,7	4,3	4,7	4,8	4,9	5,0
Quality Management Performance	3,7	4,3	4,7	4,8	4,9	5,0
Project Management Soft Skills	2,7	2,7	2,7	2,7	2,7	2,7

Run

Figure 40: Results Interface / Project Management Perspective-1

MODEL OUTPUT PARAMETERS //
P4: PROJECT MANAGEMENT PERSPECTIVE

Cost Management Performance

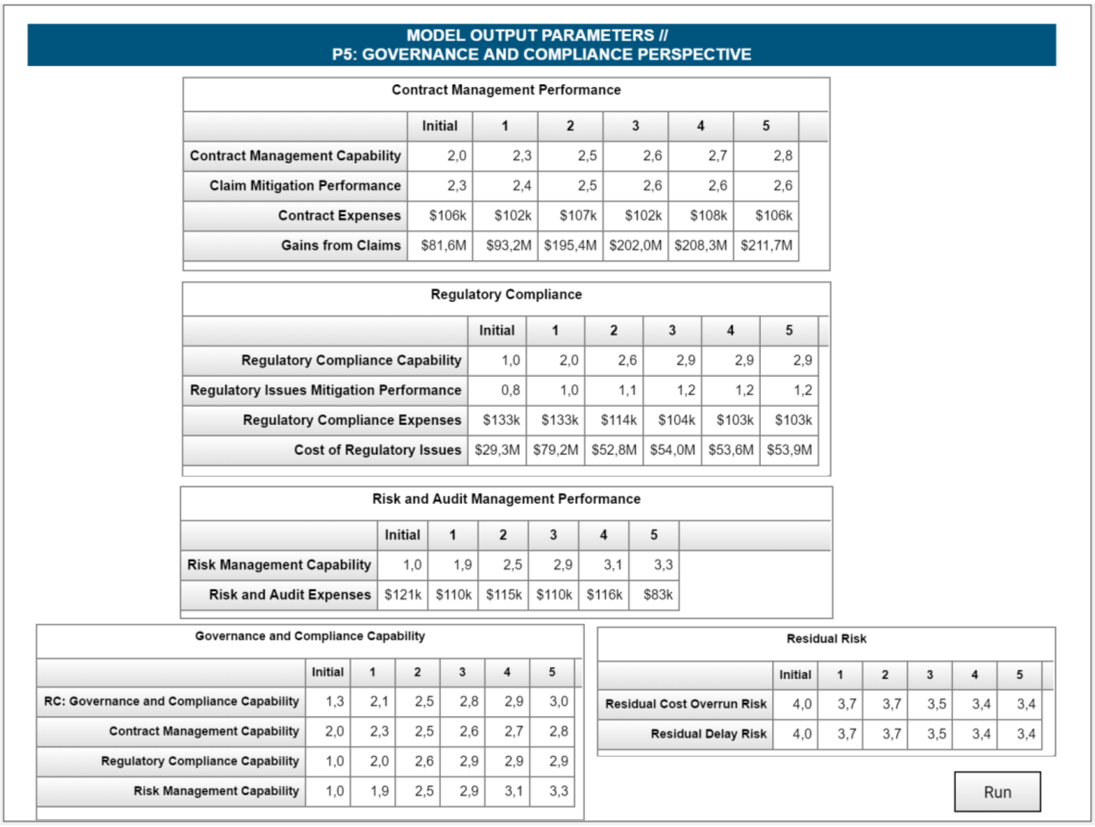
	Initial	1	2	3	4	5
Total Remaining Project Budget	$2.250,0M	$2.518,7M	$5.216,5M	$5.336,0M	$5.488,7M	$5.552,6M
Budget Gain from Newly Awarded Projects		$1.393,7M	$3.957,1M	$2.727,8M	$2.820,7M	$2.808,2M
Yearly Realized Budget		$1.125,0M	$1.259,4M	$2.608,2M	$2.668,0M	$2.744,4M
Total Realized Budget	$0,0M	$1.125,0M	$2.384,4M	$4.992,6M	$7.660,6M	$10.405,0M
Total Earned Budget for Work Performed	$0,0M	$948,5M	$2.069,2M	$4.301,3M	$6.709,0M	$9.090,1M
Total Estimated Cost to Complete	$2.250,0M	$2.695,2M	$5.531,6M	$6.027,3M	$6.440,3M	$6.867,4M
Total Cost Variation	$0,0M	$176,5M	$315,2M	$691,3M	$951,6M	$1.314,8M
Cost Overrun (%)	0,0%	15,7%	13,2%	13,8%	12,4%	12,6%

Time Management Performance

	Initial	1	2	3	4	5
Total Realized Project Duration	0,0	1,0	2,0	3,0	4,0	5,0
Total Earned Duration for Work Performed	0,0	0,9	1,9	2,9	4,0	5,0
"Ave. Actual Project Duration"	2,0	2,1	2,1	2,1	2,0	2,0
"Ave. Planned Project Duration"	2,0	2,0	2,0	2,0	2,0	2,0
"Ave. Schedule Variation	0,0	0,1	0,1	0,1	0,0	0,0

Run

Figure 41: Results Interface / Project Management Perspective-2



MODEL OUTPUT PARAMETERS //
P5: GOVERNANCE AND COMPLIANCE PERSPECTIVE

Contract Management Performance

	Initial	1	2	3	4	5
Contract Management Capability	2,0	2,3	2,5	2,6	2,7	2,8
Claim Mitigation Performance	2,3	2,4	2,5	2,6	2,6	2,6
Contract Expenses	$106k	$102k	$107k	$102k	$108k	$106k
Gains from Claims	$81,6M	$93,2M	$195,4M	$202,0M	$208,3M	$211,7M

Regulatory Compliance

	Initial	1	2	3	4	5
Regulatory Compliance Capability	1,0	2,0	2,6	2,9	2,9	2,9
Regulatory Issues Mitigation Performance	0,8	1,0	1,1	1,2	1,2	1,2
Regulatory Compliance Expenses	$133k	$133k	$114k	$104k	$103k	$103k
Cost of Regulatory Issues	$29,3M	$79,2M	$52,8M	$54,0M	$53,6M	$53,9M

Risk and Audit Management Performance

	Initial	1	2	3	4	5
Risk Management Capability	1,0	1,9	2,5	2,9	3,1	3,3
Risk and Audit Expenses	$121k	$110k	$115k	$110k	$116k	$83k

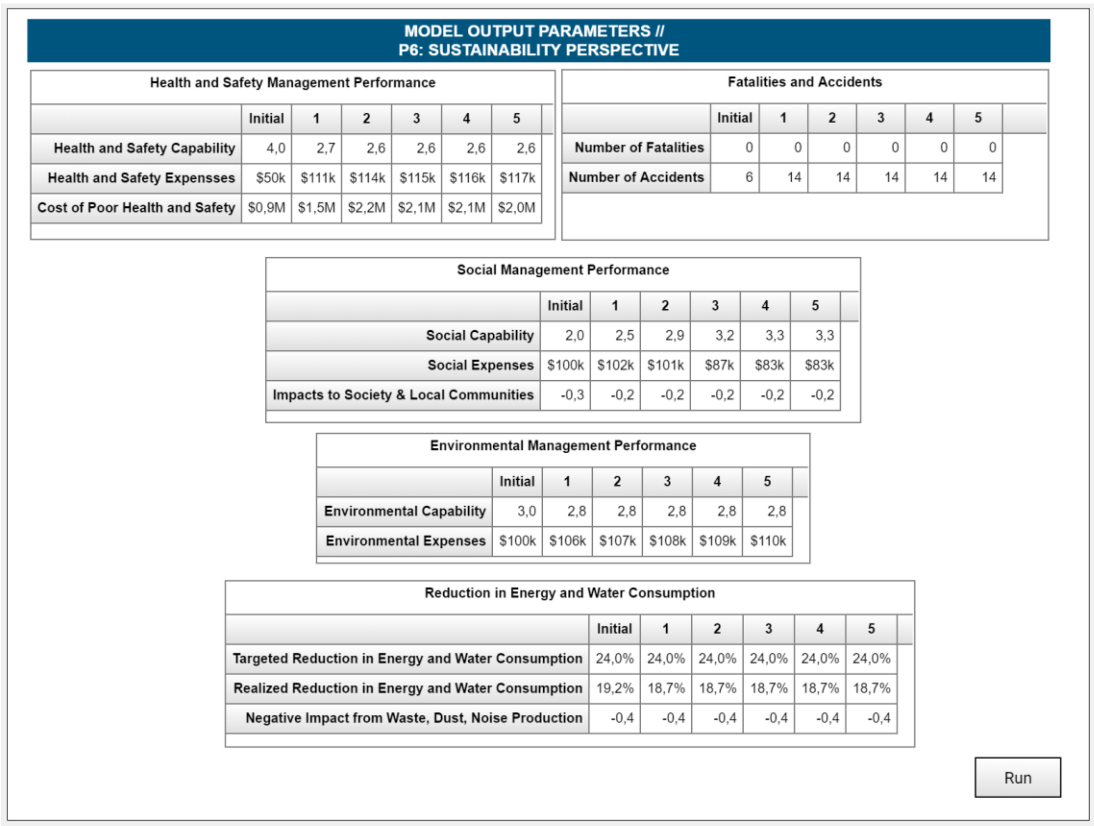
Governance and Compliance Capability

	Initial	1	2	3	4	5
RC: Governance and Compliance Capability	1,3	2,1	2,5	2,8	2,9	3,0
Contract Management Capability	2,0	2,3	2,5	2,6	2,7	2,8
Regulatory Compliance Capability	1,0	2,0	2,6	2,9	2,9	2,9
Risk Management Capability	1,0	1,9	2,5	2,9	3,1	3,3

Residual Risk

	Initial	1	2	3	4	5
Residual Cost Overrun Risk	4,0	3,7	3,7	3,5	3,4	3,4
Residual Delay Risk	4,0	3,7	3,7	3,5	3,4	3,4

Figure 42: Results Interface / Governance and Compliance Perspective



MODEL OUTPUT PARAMETERS //
P6: SUSTAINABILITY PERSPECTIVE

Health and Safety Management Performance

	Initial	1	2	3	4	5
Health and Safety Capability	4,0	2,7	2,6	2,6	2,6	2,6
Health and Safety Expensses	$50k	$111k	$114k	$115k	$116k	$117k
Cost of Poor Health and Safety	$0,9M	$1,5M	$2,2M	$2,1M	$2,1M	$2,0M

Fatalities and Accidents

	Initial	1	2	3	4	5
Number of Fatalities	0	0	0	0	0	0
Number of Accidents	6	14	14	14	14	14

Social Management Performance

	Initial	1	2	3	4	5
Social Capability	2,0	2,5	2,9	3,2	3,3	3,3
Social Expenses	$100k	$102k	$101k	$87k	$83k	$83k
Impacts to Society & Local Communities	-0,3	-0,2	-0,2	-0,2	-0,2	-0,2

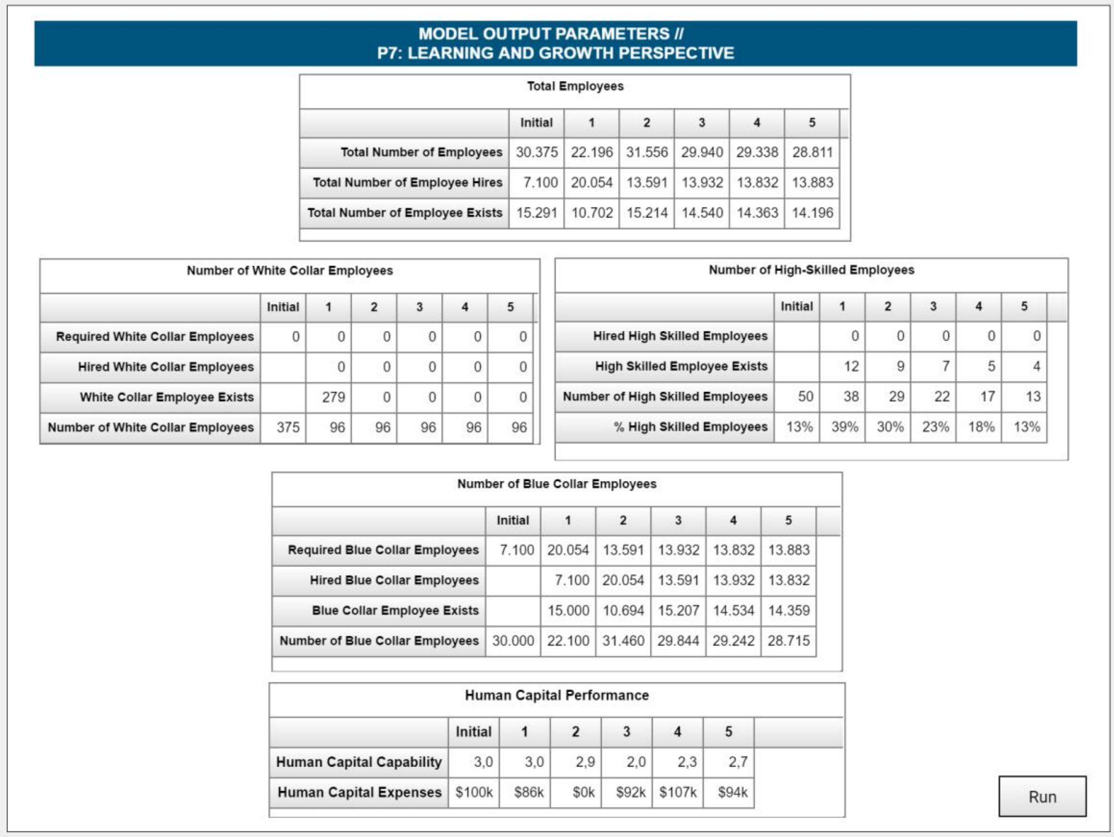
Environmental Management Performance

	Initial	1	2	3	4	5
Environmental Capability	3,0	2,8	2,8	2,8	2,8	2,8
Environmental Expenses	$100k	$106k	$107k	$108k	$109k	$110k

Reduction in Energy and Water Consumption

	Initial	1	2	3	4	5
Targeted Reduction in Energy and Water Consumption	24,0%	24,0%	24,0%	24,0%	24,0%	24,0%
Realized Reduction in Energy and Water Consumption	19,2%	18,7%	18,7%	18,7%	18,7%	18,7%
Negative Impact from Waste, Dust, Noise Production	-0,4	-0,4	-0,4	-0,4	-0,4	-0,4

Figure 43: Results Interface / Sustainability Perspective



MODEL OUTPUT PARAMETERS //
P7: LEARNING AND GROWTH PERSPECTIVE

Total Employees

	Initial	1	2	3	4	5
Total Number of Employees	30.375	22.196	31.556	29.940	29.338	28.811
Total Number of Employee Hires	7.100	20.054	13.591	13.932	13.832	13.883
Total Number of Employee Exists	15.291	10.702	15.214	14.540	14.363	14.196

Number of White Collar Employees

	Initial	1	2	3	4	5
Required White Collar Employees	0	0	0	0	0	0
Hired White Collar Employees		0	0	0	0	0
White Collar Employee Exists		279	0	0	0	0
Number of White Collar Employees	375	96	96	96	96	96

Number of High-Skilled Employees

	Initial	1	2	3	4	5
Hired High Skilled Employees		0	0	0	0	0
High Skilled Employee Exists		12	9	7	5	4
Number of High Skilled Employees	50	38	29	22	17	13
% High Skilled Employees	13%	39%	30%	23%	18%	13%

Number of Blue Collar Employees

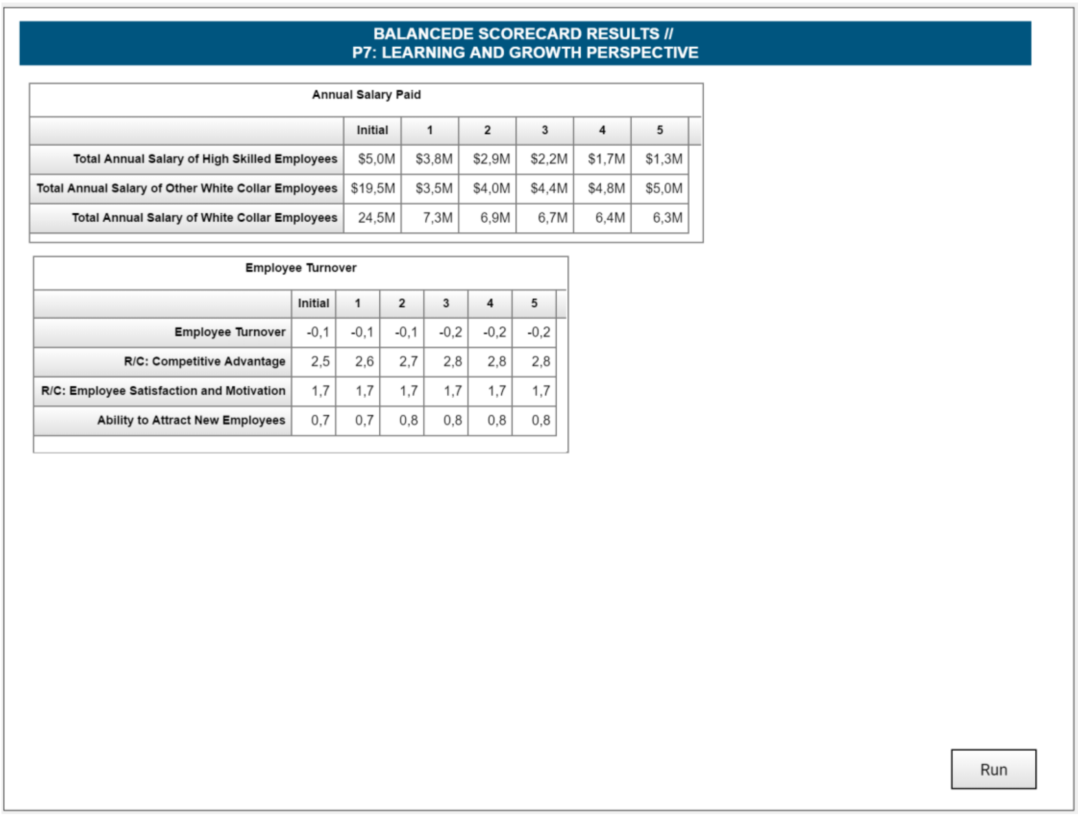
	Initial	1	2	3	4	5
Required Blue Collar Employees	7.100	20.054	13.591	13.932	13.832	13.883
Hired Blue Collar Employees		7.100	20.054	13.591	13.932	13.832
Blue Collar Employee Exists		15.000	10.694	15.207	14.534	14.359
Number of Blue Collar Employees	30.000	22.100	31.460	29.844	29.242	28.715

Human Capital Performance

	Initial	1	2	3	4	5
Human Capital Capability	3,0	3,0	2,9	2,0	2,3	2,7
Human Capital Expenses	$100k	$86k	$0k	$92k	$107k	$94k

Run

Figure 44: Results Interface/ Learning and Growth Perspective-1



BALANCEDE SCORECARD RESULTS //
P7: LEARNING AND GROWTH PERSPECTIVE

Annual Salary Paid

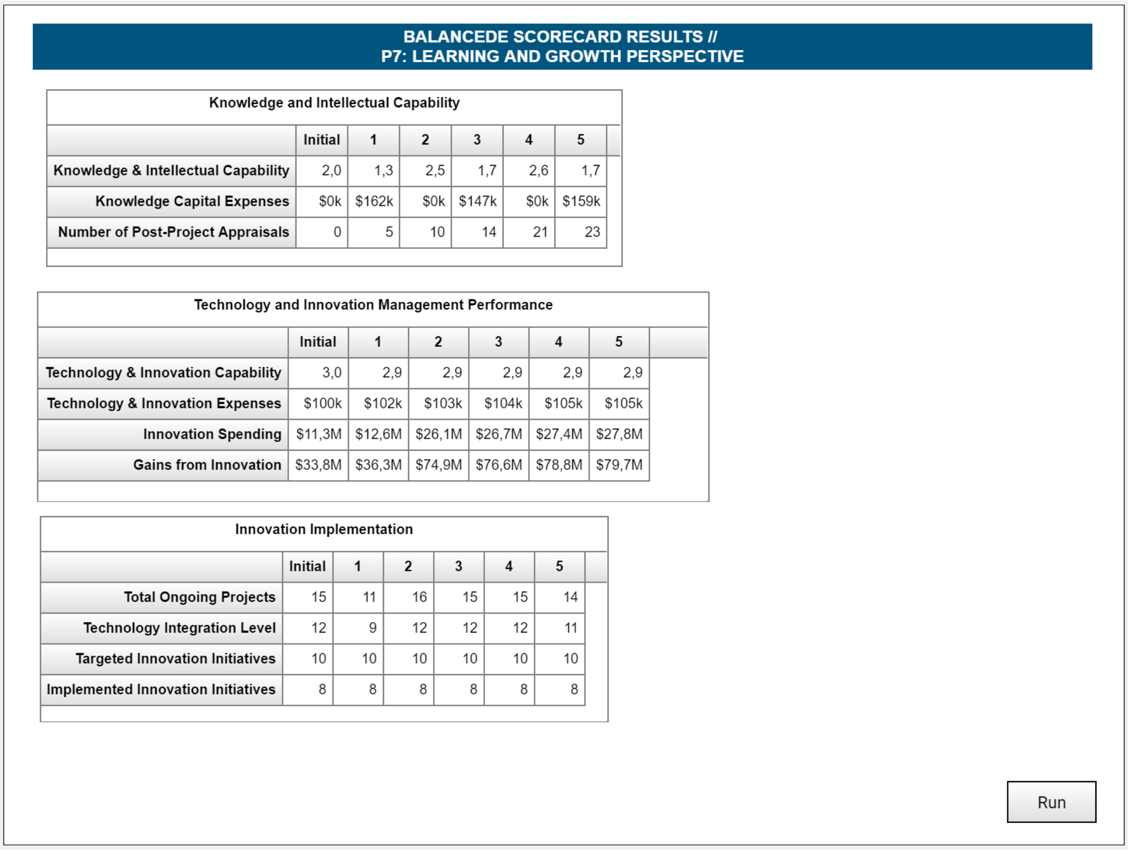
	Initial	1	2	3	4	5
Total Annual Salary of High Skilled Employees	$5,0M	$3,8M	$2,9M	$2,2M	$1,7M	$1,3M
Total Annual Salary of Other White Collar Employees	$19,5M	$3,5M	$4,0M	$4,4M	$4,8M	$5,0M
Total Annual Salary of White Collar Employees	24,5M	7,3M	6,9M	6,7M	6,4M	6,3M

Employee Turnover

	Initial	1	2	3	4	5
Employee Turnover	-0,1	-0,1	-0,1	-0,2	-0,2	-0,2
R/C: Competitive Advantage	2,5	2,6	2,7	2,8	2,8	2,8
R/C: Employee Satisfaction and Motivation	1,7	1,7	1,7	1,7	1,7	1,7
Ability to Attract New Employees	0,7	0,7	0,8	0,8	0,8	0,8

Run

Figure 45: Results Interface / Learning and Growth Perspective-2



BALANCEDE SCORECARD RESULTS //
P7: LEARNING AND GROWTH PERSPECTIVE

Knowledge and Intellectual Capability

	Initial	1	2	3	4	5
Knowledge & Intellectual Capability	2,0	1,3	2,5	1,7	2,6	1,7
Knowledge Capital Expenses	$0k	$162k	$0k	$147k	$0k	$159k
Number of Post-Project Appraisals	0	5	10	14	21	23

Technology and Innovation Management Performance

	Initial	1	2	3	4	5
Technology & Innovation Capability	3,0	2,9	2,9	2,9	2,9	2,9
Technology & Innovation Expenses	$100k	$102k	$103k	$104k	$105k	$105k
Innovation Spending	$11,3M	$12,6M	$26,1M	$26,7M	$27,4M	$27,8M
Gains from Innovation	$33,8M	$36,3M	$74,9M	$76,6M	$78,8M	$79,7M

Innovation Implementation

	Initial	1	2	3	4	5
Total Ongoing Projects	15	11	16	15	15	14
Technology Integration Level	12	9	12	12	12	11
Targeted Innovation Initiatives	10	10	10	10	10	10
Implemented Innovation Initiatives	8	8	8	8	8	8

Run

Figure 46: Results Interface / Learning and Growth Perspective-3

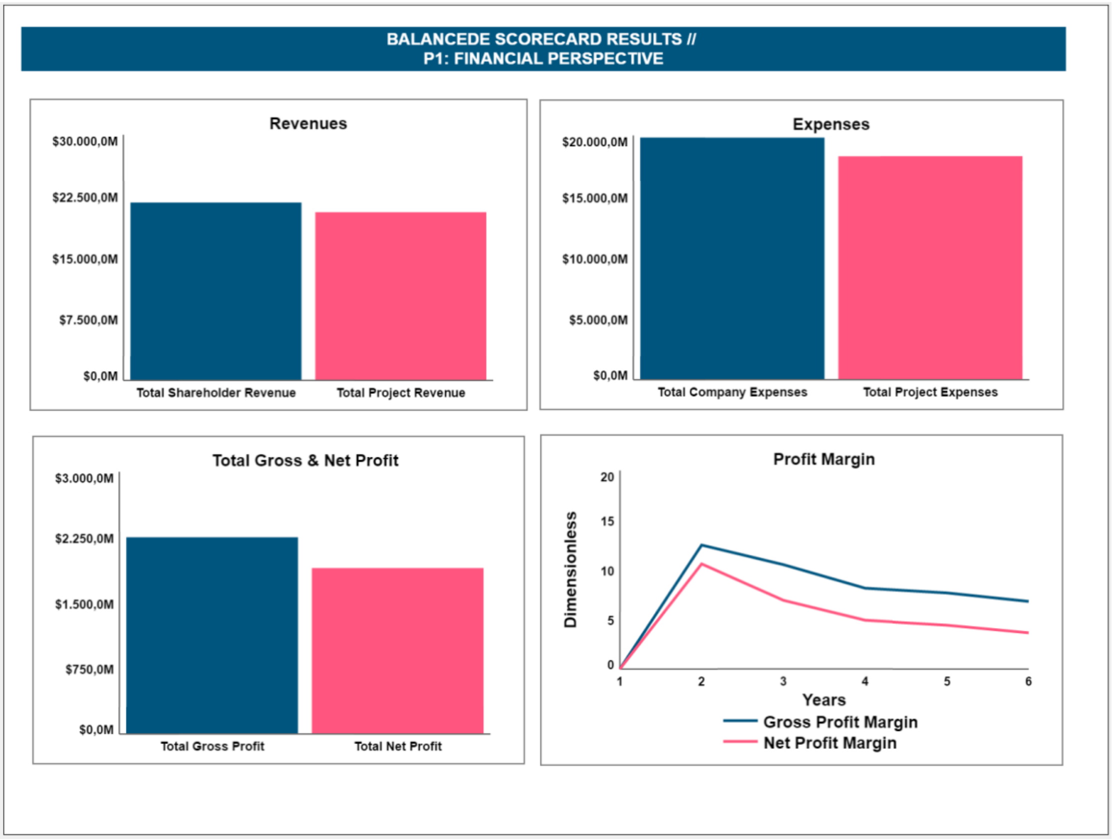


Figure 47: Dashboard Interface / Financial Perspective

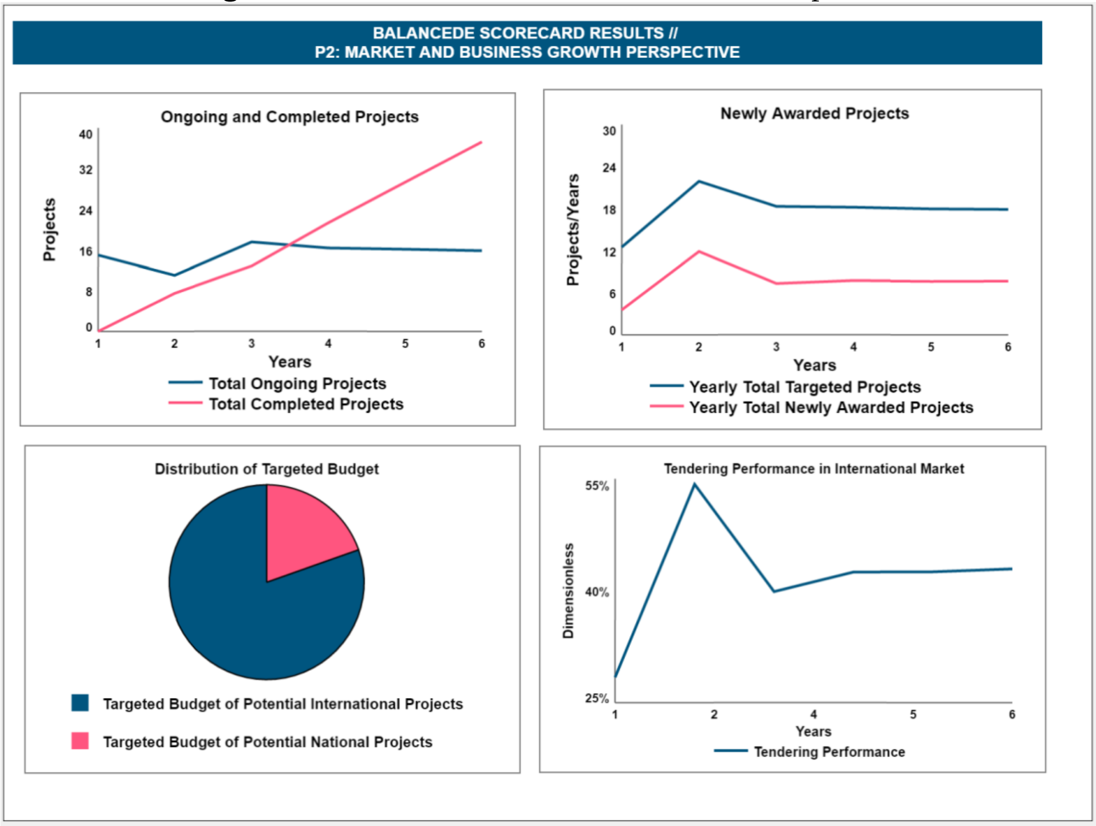


Figure 48: Dashboard Interface / Market and Business Growth Perspective

Figure 49: Dashboard Interface / Project Management Perspective

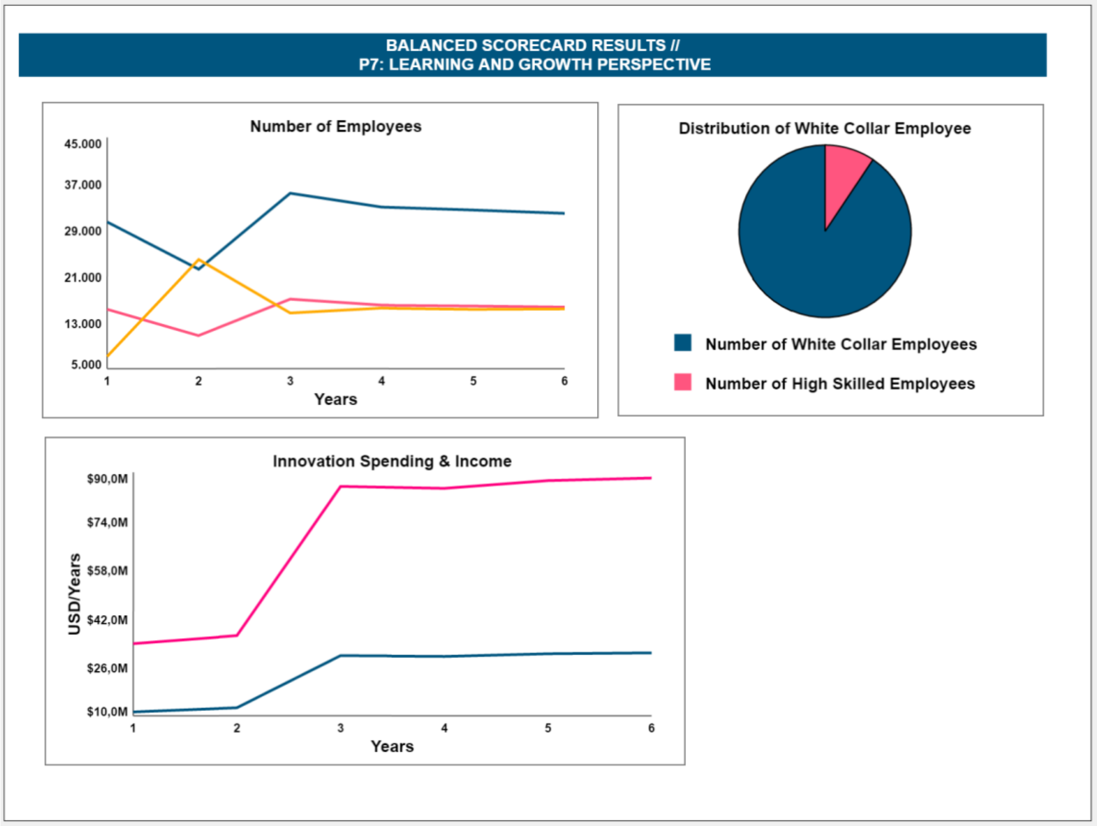


Figure 50: Dashboard Interface / Learning and Growth Perspective

APPENDIX 11: KEY FINDINGS OF THE BASELINE TESTING

Table 94: Inputs Defined for Baseline Testing

Perspective	Parameter	Units	Baseline
Financial	Min Limit for Contract Profit Margin	Dimensionless	2
Financial	Max Limit for Contract Profit Margin	Dimensionless	15
Financial	VAT %	Dimensionless	0,18
Financial	Initial Budget of National Projects	USD	$ 50m
Financial	Initial Budget of International Projects	USD	$ 200m
Market and Business Growth	Market Ave. Contract Markup	Dimensionless	10
Market and Business Growth	Initial Ongoing National Projects	Projects	5
Market and Business Growth	Initial Ongoing International Projects	Projects	10
Market and Business Growth	Manageable Max Number of National Projects	Projects	30
Market and Business Growth	Manageable Max Number of International Projects	Projects	30
Governance and Compliance	Claim/ Budget Ratio	Dimensionless	0,1
Governance and Compliance	Regulatory Issues/ Budget Ratio	Dimensionless	0,05
Sustainability	Ave. Accident/ Employee Ratio	Accidents/Employees	0,01
Sustainability	Ave. Accident Cost	USD/Accidents	$ 10k
Sustainability	Ave. Fatality Cost	USD/Accidents	$ 100k
Learning and Growth	Ave. Number of Blue Collar Employee/Project	Employees/ Projects	2k
Learning and Growth	Ave. Annual Salary Provided to High Skilled Employees	USD	$ 100k
Learning and Growth	Ave. Annual Salary Provided to Other White Collar Employees	USD	$ 60k
Learning and Growth	Ave. Number of White Collar Employee/Project	Employees/Projects	25

Learning and Growth	UnitCost for Medium Level Req. for Org. Competence	USD	$ 50k
Learning and Growth	UnitCost for High Level Req. for Org. Competence	USD	$ 100k
Learning and Growth	Unit Cost for Low Level Req. for Org. Competence	USD	$ 10k
Project Management	Ave. Planned Project Duration	Years	2
Learning and Growth	Initial: Number of While Collar Employees	Employees	375
Learning and Growth	Initial: Number of Blue Collar Employees	Employees	30000
Learning and Growth	Initial: Number of High Skilled Employees	Employees	50
Learning and Growth	Min Number of Blue Collar Employees	Employees	1000

Table 95: Key Outputs of Scenario Testing / Baseline Scenario

Baseline Scenario								
Key Outputs	**Unit**	**Simulation Year**						
Contract Markup and Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Contract Profit Margin	%	10,3%	10,3%	10,3%	10,3%	10,3%	10,3%
Project Budgets		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Budget of Newly Awarded Projects	m$		1.394	3.957	2.728	2.821	2.808
Targeted Budget of Potential National Projects	Projects	96	96	98	99	99	99
Targeted Budget of Potential International Projects	Projects	393	395	401	405	406	407
Revenues		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Shareholder Revenue	m$	-	3.096	9.167	12.647	16.236	19.815
Yearly Shareholder Revenue	m$		3.096	6.071	3.480	3.589	3.579
Total Project Revenue	m$	-	2.981	8.923	12.132	15.443	18.735
Yearly Project Revenue	m$		2.981	5.942	3.209	3.311	3.292

Expenses		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Company Expenses	m$	-	2.561	8.014	11.263	14.686	18.112
Yearly Company Expenses	m$		2.561	5.453	3.249	3.423	3.427
Total Project Expenses	m$	-	2.519	7.741	10.626	13.678	16.724
Yearly Project Expenses	m$		2.519	5.222	2.885	3.051	3.046
Total General & Administrative Expenses	m$	-	42	137	219	302	386
Yearly G&A Expenses	m$		42	94	82	84	84
Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Gross Profit	m$		462	720	324	260	246
Total Gross Profit	m$	-	462	1.182	1.506	1.765	2.011
Gross Profit Margin	%	-	12	10	8	7	7
Yearly Net Profit	m$		535	619	231	166	152
Total Net Profit	m$	-	535	1.154	1.385	1.551	1.703
Net Profit Margin	%	-	10	7	5	4	4
Project Portfolio		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Targeted Projects	Projects	13	19	17	16	16	16
Yearly Total Newly Awarded Projects	Projects	4	10	7	7	7	7
Total Completed Projects	Projects	0	8	13	20	28	35
Total Ongoing Projects	Projects	15	11	16	15	15	14
Tendering Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Tendering Performance	%	28%	52%	41%	42%	43%	43%
Attractiveness of International Construction Market	-	1,5	1,5	1,5	1,5	1,5	1,5
Attractiveness of National Construction Market	-	1,3	1,3	1,3	1,3	1,3	1,3
R/C: Competitive Advantage		2,5	2,6	2,7	2,8	2,8	2,8

International Projects		Initial	1	2	3	4	5
Targeted Number of International Projects	Projects	10,0	18,0	16,0	16,0	16,0	16,0
Newly Awarded International Projects	Projects		4,0	10,0	7,0	7,0	7,0
Completed International Projects	Projects	0,0	5,0	9,0	16,0	23,0	30,0
National Projects Completion Rate		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of National Projects	Projects	3	1	1	0	0	0
Newly Awarded National Projects	Projects		0	0	0	0	0
Completed National Projects	Projects	0	3	4	4	5	5
Cost Management Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Realized Budget	m$	-	1.125	2.384	4.993	7.661	10.405
Total Earned Budget for Work Performed	m$	-	949	2.069	4.301	6.709	9.090
Total Estimated Cost to Complete	m$	2.250	2.695	5.532	6.027	6.440	6.867
Total Cost Variation	m$	-	177	315	691	952	1.315
Cost Overrun (%)	%	0%	16%	13%	14%	12%	13%
Facilities and Accidents		**Initial**	**1**	**2**	**3**	**4**	**5**
Number of Fatalities	Employees	0	0	0	0	0	0
Number of Accidents	Employees	6	14	14	14	14	14
Total Employees		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Number of Employees	Employees	30.375	22.196	31.556	29.940	29.338	28.811
Total Number of Employee Hires	Employees	7.100	20.054	13.591	13.932	13.832	13.883
Total Number of Employee Exists	Employees	15.291	10.702	15.214	14.540	14.363	14.196

APPENDIX 12: KEY FINDINGS OF THE SCENARIO TESTING

Table 96: Inputs Defined for Scenario Testing

Perspective	Parameter	Baseline	Scenario 1	Scenario 7	Scenario 16
Market and Business Growth	G/M: Country Political Stabiltiy	1	3	3	-4
Market and Business Growth	G/M: Country Economic Growth and Development	-1	3	2	-4
Market and Business Growth	G/M: National Demand	4	5	1	-3
Market and Business Growth	G/M: Strength of National Competitiors	3	1	0	-3
Market and Business Growth	G/M: Strength of International Competitors	4	3	2	-1
Market and Business Growth	G/M: Global Political Stabiltiy	1	4	3	-2
Market and Business Growth	G/M: Global Economic Growth and Development	2	4	3	-2
Market and Business Growth	G/M: Favorability of International Relations	1	4	3	-2
Market and Business Growth	G/M: Global Demand	2	4	0	-2
Stakeholder	G/M: Level of Client Expectations	4	5	3	1
Stakeholder	G/M: Power of Media	2	2	3	4
Stakeholder	G/M: Level of Society Demands	1	3	4	5
Stakeholder	R/C: Relations with Media	2	2	2	2
Stakeholder	GM: Level of Creditor Expectations	4	2	3	5
Stakeholder	R/C: Relations with Creditors	2	2	2	2
Stakeholder	R/C: Corporate Financial Strength	2	2	2	2
Stakeholder	Initial: Client Satisfaction and Loyalty	3	3	3	3
Stakeholder	Initial: Reputation	2	2	2	2
Stakeholder	Initial: Creditor and Financial Resource Availability	3	3	3	3

Project Management	R/C: Relations with Subcontractor/ Suppliers	4	4	4	4
Project Management	G/M: Market Availability of Material/ Equipment	3	5	2	-1
Project Management	GM: Competency of Subcontractors/ Suppliers	2	4	2	-3
Project Management	GM: Market Availability of Labor	4	4	2	0
Project Management	GM: Competency of Designer/ Engineer	4	5	2	-2
Project Management	RC: Relations with Designer/ Engineers	4	4	4	4
Project Management	RC: Communication & Coordination Management Capability	4	4	4	4
Project Management	RC: Integration Management Capability	2	2	2	2
Project Management	RC: Scope Management Capability	2	2	2	2
Project Management	Initial: Supply Chain Management Capability	4	4	4	4
Project Management	Initial: Site Management Capability	4	4	4	4
Project Management	Initial: Design and Engineering Capability	3	3	3	3
Governance and Compliance	RC: Relations with Major Clients	4	4	4	4
Governance and Compliance	GM: Maturity of Laws and Regulations	1	5	3	1
Governance and Compliance	RC: Performance of Claim/ Dispute Resolution Method	2	2	2	2
Governance and Compliance	RC: Performance of Contract Management System	3	3	3	3
Governance and Compliance	R/C: Relations with Regulatory Bodies	4	4	4	4
Governance and Compliance	Project Time Delay Risk Level	4	4	4	4
Governance and Compliance	Project Cost Overrun Risk Level	4	4	4	4
Governance and Compliance	R/C: Performance of Risk Management System	3	3	3	3
Governance and Compliance	R/C: Performance of Internal Control and Audit System	1	1	1	1
Governance and Compliance	Initial: Contract Management Capability	2	2	2	2
Governance and Compliance	Initial: Regulatory Compliance Capability	1	1	1	1
Governance and Compliance	Initial: Risk and Audit Capability	1	1	1	1

Governance and Compliance	G/M: Strictness of Bureaucracy	3	4	3	0
Sustainability	RC: Performance of H&S training, audit and inspections	5	5	5	5
Sustainability	RC: Performance of H&S management system	4	4	4	4
Sustainability	GM: Strictness of HS Regulations	4	2	3	5
Sustainability	Project H&S Risk Level	3	3	3	3
Sustainability	RC: Performance of environmental training, audit and inspections	4	4	4	4
Sustainability	RC: Performance of environmental management system	3	3	3	3
Sustainability	GM: Strictness of Environmental Regulations	3	2	4	5
Sustainability	Project Environmental Risk Level	2	2	2	2
Sustainability	RC: Compliance to Human Rights, Equal Employment and Diversity	2	2	2	2
Sustainability	RC: Availability of Social Responsibility Initiatives	2	2	2	2
Sustainability	GM: Strictness of Social Requirements	0	0	3	4
Sustainability	Project Social Impact Risk Level	1	1	1	1
Sustainability	Initial: Health and Safety Capability	4	4	4	4
Sustainability	Initial Environmental Capability	3	3	3	3
Sustainability	Initial: Social Capability	2	2	2	2
Learning and Growth	R/C: Maturity in Automation and Digitization	2	2	2	2
Learning and Growth	R/C: Maturity of IT Applications	2	2	2	2
Learning and Growth	G/M: Advances in Technology	5	5	0	-3
Learning and Growth	G/M: Benefits Provided for Innovation	1	4	0	-3
Learning and Growth	R/C: Organizational Effectiveness	4	4	4	4
Learning and Growth	R/C: Organizational Learning	3	3	3	3
Learning and Growth	G/M: Advances in Organizational Studies	4	4	0	-2

Learning and Growth	G/M: Availability of Skilled Employee	2	5	-1	-4
Learning and Growth	G/M: Industry Reputation	-2	4	0	-4
Learning and Growth	R/C: Employee Engagement	1	1	1	1
Learning and Growth	R/C: Maturity of HR Applications	2	2	2	2
Learning and Growth	R/C: Employee Training	2	2	2	2
Learning and Growth	Initial: Technology & Innovation Capability	3	3	3	3
Learning and Growth	Initial: Knowledge Capability	2	2	2	2
Learning and Growth	Initial: Human Capital	3	3	3	3
Learning and Growth	G/M: Advances in HR Applications	3	5	1	-2

Table 97: Key Outputs of Scenario Testing / Scenario 1

Scenario 1							
Key Outputs	**Unit**	**Simulation Year**					
Contract Markup and Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Contract Profit Margin	%	13,5%	13,5%	13,5%	13,5%	13,5%	13,5%
Project Budgets		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Budget of Newly Awarded Projects	m$		1.930	6.597	4.082	4.358	4.319
Targeted Budget of Potential National Projects	Projects	131	132	135	135	136	136
Targeted Budget of Potential International Projects	Projects	544	549	559	563	564	564
Revenues		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Shareholder Revenue	m$	-	3.838	13.306	18.715	24.444	30.137
Yearly Shareholder Revenue	m$		3.838	9.468	5.409	5.730	5.693
Total Project Revenue	m$	-	3.711	13.003	17.938	23.191	28.391

Yearly Project Revenue	m$		3.711	9.292	4.934	5.254	5.200
Expenses		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Company Expenses	m$	-	3.091	11.210	15.993	21.186	26.381
Yearly Company Expenses	m$		3.091	8.119	4.782	5.194	5.195
Total Project Expenses	m$	-	3.055	10.919	15.176	19.842	24.493
Yearly Project Expenses	m$		3.055	7.864	4.258	4.666	4.650
Total General & Administrative Expenses	m$	-	36	127	213	301	390
Yearly G&A Expenses	m$		36	90	86	88	89
Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Gross Profit	m$		656	1.428	677	588	550
Total Gross Profit	m$	-	656	2.085	2.761	3.349	3.899
Gross Profit Margin	%	-	15	14	11	11	10
Yearly Net Profit	m$		747	1.349	627	536	498
Total Net Profit	m$	-	747	2.096	2.722	3.258	3.756
Net Profit Margin	%	-	14	12	9	9	8
Project Portfolio		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Targeted Projects	Projects	13	22	18	18	18	18
Yearly Total Newly Awarded Projects	Projects	4	12	7	8	8	8
Total Completed Projects	Projects	0	8	13	21	29	37
Total Ongoing Projects	Projects	15	11	18	16	16	16
Tendering Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Tendering Performance	%	28%	55%	40%	43%	43%	43%
Attractiveness of International Construction Market	-	4,0	4,0	4,0	4,0	4,0	4,0
Attractiveness of National Construction Market	-	3,7	3,7	3,7	3,7	3,7	3,7

International Projects		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of International Projects	Projects	10	21	18	18	18	18
Newly Awarded International Projects	Projects		4	12	7	8	8
Completed International Projects	Projects	-	5	9	17	25	33
National Projects Completion Rate		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of National Projects	Projects	3	1	1	-	-	-
Newly Awarded National Projects	Projects		-	-	-	-	-
Completed National Projects	Projects	-	3	4	4	5	5
Cost Management Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Realized Budget	m$	-	1.125	2.652	6.715	10.787	15.002
Total Earned Budget for Work Performed	m$	-	947	2.301	5.789	9.460	13.136
Total Estimated Cost to Complete	m$	2.250	3.233	8.476	9.070	9.757	10.399
Total Cost Variation	m$	-	178	351	925	1.327	1.866
Cost Overrun (%)	%	0%	16%	13%	14%	12%	12%
Facilities and Accidents		**Initial**	**1**	**2**	**3**	**4**	**5**
Number of Fatalities	Employees	-	-	-	-	-	-
Number of Accidents	Employees	6	11	12	12	12	12
Total Employees		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Number of Employees	Employees	30.375	22.237	35.687	33.095	32.554	31.972
Total Number of Employee Hires	Employees	7.100	24.172	14.609	15.493	15.318	15.337
Total Number of Employee Exists	Employees	15.245	10.717	17.208	16.039	15.904	15.722

Table 98: Key Outputs of Scenario Testing / Scenario 7

Scenario 7							
Key Outputs	**Unit**	**Simulation Year**					
Contract Markup and Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Contract Profit Margin	%	11,3%	11,3%	11,3%	11,3%	11,3%	11,3%
Project Budgets		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Budget of Newly Awarded Projects	m$		1.555	5.258	3.247	3.455	3.436
Targeted Budget of Potential National Projects	Projects	106	106	108	109	109	109
Targeted Budget of Potential International Projects	Projects	438	441	447	450	451	451
Revenues		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Shareholder Revenue	m$	-	3.384	11.158	15.622	20.323	25.013
Yearly Shareholder Revenue	m$		3.384	7.774	4.464	4.701	4.690
Total Project Revenue	m$	-	3.196	10.728	14.580	18.670	22.730
Yearly Project Revenue	m$		3.196	7.532	3.852	4.090	4.061
Expenses		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Company Expenses	m$	-	2.738	9.509	13.410	17.587	21.810
Yearly Company Expenses	m$		2.738	6.771	3.901	4.178	4.222
Total Project Expenses	m$	-	2.680	9.189	12.588	16.266	19.976
Yearly Project Expenses	m$		2.680	6.510	3.399	3.678	3.710
Total General & Administrative Expenses	m$	-	59	175	321	467	616
Yearly G&A Expenses	m$		59	116	145	147	149
Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Gross Profit	m$		516	1.022	453	412	351
Total Gross Profit	m$	-	516	1.539	1.992	2.404	2.755

Gross Profit Margin	%	-	14	12	10	9	9
Yearly Net Profit	m$		646	1.003	563	523	468
Total Net Profit	m$	-	646	1.649	2.212	2.735	3.203
Net Profit Margin	%	-	13	13	11	10	10
Project Portfolio		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Targeted Projects	Projects	13	22	18	18	18	18
Yearly Total Newly Awarded Projects	Projects	4	12	7	8	8	8
Total Completed Projects	Projects	0	8	13	21	29	37
Total Ongoing Projects	Projects	15	11	18	16	16	16
Tendering Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Tendering Performance	%	28%	55%	40%	42%	42%	43%
Attractiveness of International Construction Market	-	2,3	2,3	2,3	2,3	2,3	2,3
Attractiveness of National Construction Market	-	2,0	2,0	2,0	2,0	2,0	2,0
International Projects		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of International Projects	Projects	10	21	18	18	18	18
Newly Awarded International Projects	Projects		4	12	7	8	8
Completed International Projects	Projects	-	5	9	17	25	32
National Projects Completion Rate		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of National Projects	Projects	3	1	1	-	-	-
Newly Awarded National Projects	Projects		-	-	-	-	-
Completed National Projects	Projects	-	3	4	4	5	5
Cost Management Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Realized Budget	m$	-	1.125	2.465	5.764	9.036	12.400
Total Earned Budget for Work Performed	m$	-	962	2.160	5.097	7.941	11.086

Total Estimated Cost to Complete	m$	2.250	2.843	6.903	7.213	7.823	8.114
Total Cost Variation	m$	-	163	305	667	1.095	1.314
Cost Overrun (%)	%	0%	15%	12%	12%	12%	11%
Facilities and Accidents		**Initial**	**1**	**2**	**3**	**4**	**5**
Number of Fatalities	Employees	-	-	-	-	-	-
Number of Accidents	Employees	6	13	13	13	13	13
Total Employees		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Number of Employees	Employees	30.375	22.220	35.454	32.915	32.329	31.774
Total Number of Employee Hires	Employees	7.100	23.956	14.521	15.367	15.237	15.237
Total Number of Employee Exists	Employees	15.264	10.721	17.067	15.959	15.797	15.628

Table 99: Key Outputs of Scenario Testing / Scenario 16

Scenario 16							
Key Outputs	**Unit**	**Simulation Year**					
Contract Markup and Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Contract Profit Margin	%	4,8%	4,8%	4,8%	4,8%	4,8%	4,8%
Project Budgets		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Budget of Newly Awarded Projects	m$		-	-	-	-	-
Targeted Budget of Potential National Projects	Projects	20	20	20	21	21	21
Targeted Budget of Potential International Projects	Projects	181	181	183	184	185	186
Revenues		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Shareholder Revenue	m$	-	1.452	2.772	2.824	2.850	2.863
Yearly Shareholder Revenue	m$		1.452	1.320	52	26	13
Total Project Revenue	m$	-	1.269	2.489	2.489	2.489	2.489

Yearly Project Revenue	m$		1.269	1.220	-	-	-
Expenses		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Company Expenses	m$	-	1.160	2.480	2.625	2.713	2.779
Yearly Company Expenses	m$		1.160	1.320	145	87	66
Total Project Expenses	m$	-	1.125	2.366	2.471	2.539	2.595
Yearly Project Expenses	m$		1.125	1.241	106	67	57
Total General & Administrative Expenses	m$	-	35	54	63	68	70
Yearly G&A Expenses	m$		35	18	9	5	2
Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Gross Profit	m$		144	-	-	-	-
Total Gross Profit	m$	-	144	144	144	144	144
Gross Profit Margin	%	-	-	-	-	-	-
Yearly Net Profit	m$		292	0	-	-	-
Total Net Profit	m$	-	292	292	292	292	292
Net Profit Margin	%	-	-	-	-	-	-
Project Portfolio		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Targeted Projects	Projects	6	3	1	1	0	0
Yearly Total Newly Awarded Projects	Projects	0	0	0	0	0	0
Total Completed Projects	Projects	0	8	11	13	14	14
Total Ongoing Projects	Projects	15	8	4	2	1	1
Tendering Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Tendering Performance	%	0%	0%	0%	0%	0%	0%
Attractiveness of International Construction Market	-	-2,0	-2,0	-2,0	-2,0	-2,0	-2,0
Attractiveness of National Construction Market	-	-3,7	-3,7	-3,7	-3,7	-3,7	-3,7

International Projects		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of International Projects	Projects	4	2	1	1	-	-
Newly Awarded International Projects	Projects		-	-	-	-	-
Completed International Projects	Projects	-	5	7	9	9	10
National Projects Completion Rate		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of National Projects	Projects	2	1	-	-	-	-
Newly Awarded National Projects	Projects		-	-	-	-	-
Completed National Projects	Projects	-	3	4	4	5	5
Cost Management Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Realized Budget	m$	-	1.125	1.688	1.969	2.109	2.180
Total Earned Budget for Work Performed	m$	-	973	1.476	1.767	1.883	1.953
Total Estimated Cost to Complete	m$	2.250	1.277	774	483	367	297
Total Cost Variation	m$	-	152	211	202	226	227
Cost Overrun (%)	%	0%	14%	13%	10%	11%	10%
Facilities and Accidents		**Initial**	**1**	**2**	**3**	**4**	**5**
Number of Fatalities	Employees	-	-	-	-	-	-
Number of Accidents	Employees	6	15	15	15	15	15
Total Employees		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Number of Employees	Employees	30.375	15.095	7.810	4.030	2.069	1.053
Total Number of Employee Hires	Employees	-	-	-	-	-	-
Total Number of Employee Exists	Employees	15.292	7.294	3.786	1.967	1.028	523

APPENDIX 13: KEY FINDINGS OF THE STRATEGIC OPTIONS TESTING

Table 100: Inputs Defined for Strategic Options Testing

Perspective	Parameter	Baseline Scenario	Strategy 1	Strategy 2	Strategy 3
Market and Business Growth	G/M: Country Political Stabiltiy	1	1	1	1
Market and Business Growth	G/M: Country Economic Growth and Development	-1	-1	-1	-1
Market and Business Growth	G/M: National Demand	4	4	4	4
Market and Business Growth	G/M: Strength of National Competitiors	3	3	3	3
Market and Business Growth	G/M: Strength of International Competitors	4	4	4	4
Market and Business Growth	G/M: Global Political Stabiltiy	1	1	1	1
Market and Business Growth	G/M: Global Economic Growth and Development	2	2	2	2
Market and Business Growth	G/M: Favorability of International Relations	1	1	1	1
Market and Business Growth	G/M: Global Demand	2	2	2	2
Stakeholder	G/M: Level of Client Expectations	4	4	4	4
Stakeholder	G/M: Power of Media	2	2	2	2
Stakeholder	G/M: Level of Society Demands	1	1	1	1
Stakeholder	R/C: Relations with Media	2	2	5	2
Stakeholder	GM: Level of Creditor Expectations	4	4	4	4
Stakeholder	R/C: Relations with Creditors	2	2	5	2
Stakeholder	R/C: Corporate Financial Strength	2	2	5	2
Stakeholder	Initial: Client Satisfaction and Loyalty	3	3	3	3
Stakeholder	Initial: Reputation	2	2	2	2

Stakeholder	Initial: Creditor and Financial Resource Availability	3	3	3	3
Project Management	R/C: Relations with Subcontractor/ Suppliers	4	4	4	5
Project Management	G/M: Market Availability of Material/ Equipment	3	3	3	3
Project Management	GM: Competency of Subcontractors/ Suppliers	2	2	2	2
Project Management	GM: Market Availability of Labor	4	4	4	4
Project Management	GM: Competency of Designer/ Engineer	4	4	4	4
Project Management	RC: Relations with Designer/ Engineers	4	4	4	5
Project Management	RC: Communication & Coordination Management Capability	4	4	4	5
Project Management	RC: Integration Management Capability	2	2	2	5
Project Management	RC: Scope Management Capability	2	2	2	5
Project Management	Initial: Supply Chain Management Capability	4	4	4	4
Project Management	Initial: Site Management Capability	4	4	4	4
Project Management	Initial: Design and Engineering Capability	3	3	3	3
Governance and Compliance	RC: Relations with Major Clients	4	4	5	4
Governance and Compliance	GM: Maturity of Laws and Regulations	1	1	1	1
Governance and Compliance	RC: Performance of Claim/ Dispute Resolution Method	2	2	5	2
Governance and Compliance	RC: Performance of Contract Management System	3	3	5	3
Governance and Compliance	R/C: Relations with Regulatory Bodies	4	4	5	4
Governance and Compliance	Project Time Delay Risk Level	4	4	4	4
Governance and Compliance	Project Cost Overrun Risk Level	4	4	4	4
Governance and Compliance	R/C: Performance of Risk Management System	3	3	5	3
Governance and Compliance	R/C: Performance of Internal Control and Audit System	1	1	5	1
Governance and Compliance	Initial: Contract Management Capability	2	2	2	2

Governance and Compliance	Initial: Regulatory Compliance Capability	1	1	1	1
Governance and Compliance	Initial: Risk and Audit Capability	1	1	1	1
Governance and Compliance	G/M: Strictness of Bureaucracy	3	3	3	3
Sustainability	RC: Performance of H&S training, audit and inspections	5	5	5	5
Sustainability	RC: Performance of H&S management system	4	4	4	5
Sustainability	GM: Strictness of HS Regulations	4	4	4	4
Sustainability	Project H&S Risk Level	3	3	3	3
Sustainability	RC: Performance of environmental training, audit and inspections	4	4	4	5
Sustainability	RC: Performance of environmental management system	3	3	3	5
Sustainability	GM: Strictness of Environmental Regulations	3	3	3	3
Sustainability	Project Environmental Risk Level	2	2	2	2
Sustainability	RC: Compliance to Human Rights, Equal Employment and Diversity	2	2	2	5
Sustainability	RC: Availability of Social Responsibiltiy Initiatives	2	2	2	5
Sustainability	GM: Strictness of Social Requirements	0	0	0	0
Sustainability	Project Social Impact Risk Level	1	1	1	1
Sustainability	Initial: Health and Safety Capability	4	4	4	4
Sustainability	Initial Environmental Capability	3	3	3	3
Sustainability	Initial: Social Capability	2	2	2	2
Learning and Growth	R/C: Maturity in Automation and Digitization	2	5	2	2
Learning and Growth	R/C: Maturity of IT Applications	2	5	2	2
Learning and Growth	G/M: Advances in Technology	5	5	5	5
Learning and Growth	G/M: Benefits Provided for Innovation	1	1	1	1

Learning and Growth	R/C: Organizational Effectiveness	4	5	4	4
Learning and Growth	R/C: Organizational Learning	3	5	3	3
Learning and Growth	G/M: Advances in Organizational Studies	4	4	4	4
Learning and Growth	G/M: Availability of Skilled Employee	2	2	2	2
Learning and Growth	G/M: Industry Reputation	-2	-2	-2	-2
Learning and Growth	R/C: Employee Engagement	1	5	1	1
Learning and Growth	R/C: Maturity of HR Applications	2	5	2	2
Learning and Growth	R/C: Employee Training	2	5	2	2
Learning and Growth	Initial: Technology & Innovation Capability	3	3	3	3
Learning and Growth	Initial: Knowledge Capability	2	2	2	2
Learning and Growth	Initial: Human Capital	3	3	3	3
Learning and Growth	G/M: Advances in HR Applications	3	3	3	3

Table 101: Key Outputs of Strategic Options Testing / Strategy 1

Strategy 1							
Key Outputs	**Unit**	**Simulation Year**					
Contract Markup and Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Contract Profit Margin	%	10,3%	10,3%	10,3%	10,3%	10,3%	10,3%
Project Budgets		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Budget of Newly Awarded Projects	m$		1.394	4.028	2.760	2.814	2.804
Targeted Budget of Potential National Projects	Projects	96	97	99	99	99	99
Targeted Budget of Potential International Projects	Projects	393	397	404	406	406	406

Revenues		Initial	1	2	3	4	5
Total Shareholder Revenue	m$	-	3.119	9.293	12.867	16.509	20.146
Yearly Shareholder Revenue	m$		3.119	6.175	3.574	3.642	3.637
Total Project Revenue	m$	-	2.981	8.998	12.236	15.536	18.823
Yearly Project Revenue	m$		2.981	6.017	3.239	3.300	3.287
Expenses		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Company Expenses	m$	-	2.561	8.012	11.231	14.534	17.843
Yearly Company Expenses	m$		2.561	5.451	3.219	3.304	3.309
Total Project Expenses	m$	-	2.519	7.740	10.591	13.519	16.446
Yearly Project Expenses	m$		2.519	5.221	2.851	2.928	2.927
Total General & Administrative Expenses	m$	-	42	137	219	302	386
Yearly G&A Expenses	m$		42	94	82	84	84
Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Gross Profit	m$		462	796	388	372	360
Total Gross Profit	m$	-	462	1.258	1.646	2.017	2.377
Gross Profit Margin	%	-	13	12	11	11	11
Yearly Net Profit	m$		558	724	355	339	328
Total Net Profit	m$	-	558	1.281	1.636	1.975	2.302
Net Profit Margin	%	-	12	10	9	9	9
Project Portfolio		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Targeted Projects	Projects	13	19	17	16	16	16
Yearly Total Newly Awarded Projects	Projects	4	10	7	7	7	7
Total Completed Projects	Projects	0	8	13	21	28	35
Total Ongoing Projects	Projects	15	11	16	15	15	14

Tendering Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Tendering Performance	%	28%	53%	41%	42%	43%	43%
Attractiveness of International Construction Market	-	1,5	1,5	1,5	1,5	1,5	1,5
Attractiveness of National Construction Market	-	1,3	1,3	1,3	1,3	1,3	1,3
R/C: Competitive Advantage		2,5	2,6	2,8	2,8	2,8	2,8
International Projects		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of International Projects	Projects	10,0	18,0	16,0	16,0	16,0	16,0
Newly Awarded International Projects	Projects		4,0	10,0	7,0	7,0	7,0
Completed International Projects	Projects	-	5,0	9,0	16,0	23,0	30,0
National Projects Completion Rate		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of National Projects	Projects	3	1	1	-	-	-
Newly Awarded National Projects	Projects		-	-	-	-	-
Completed National Projects	Projects	-	3	4	4	5	5
Cost Management Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Realized Budget	m$	-	1.125	2.384	5.028	7.730	10.488
Total Earned Budget for Work Performed	m$	-	1.021	2.202	4.686	7.237	9.843
Total Estimated Cost to Complete	m$	2.250	2.622	5.470	5.746	6.009	6.207
Total Cost Variation	m$	-	104	182	342	493	645
Cost Overrun (%)	%	0%	9%	8%	7%	6%	6%
Facilities and Accidents		**Initial**	**1**	**2**	**3**	**4**	**5**
Number of Fatalities	Employees	-	-	-	-	-	-
Number of Accidents	Employees	6	14	14	14	14	14
Total Employees		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Number of Employees	Employees	30.375	22.217	31.817	30.142	29.389	28.824

Total Number of Employee Hires	Employees	7.100	20.298	13.650	13.872	13.811	13.845
Total Number of Employee Exists	Employees	15.267	10.706	15.331	14.630	14.380	14.195

Table 102: Key Outputs of Strategic Options Testing / Strategy 2

Strategy 2							
Key Outputs	**Unit**	**Simulation Year**					
Contract Markup and Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Contract Profit Margin	%	10,3%	10,3%	10,3%	10,3%	10,3%	10,3%
Project Budgets		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Budget of Newly Awarded Projects	m$		2.796	6.641	2.943	4.302	3.771
Targeted Budget of Potential National Projects	Projects	122	120	120	120	120	120
Targeted Budget of Potential International Projects	Projects	499	493	493	493	493	493
Revenues		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Shareholder Revenue	m$	-	4.704	13.965	17.887	23.326	28.180
Yearly Shareholder Revenue	m$		4.704	9.260	3.922	5.439	4.854
Total Project Revenue	m$	-	4.575	13.622	17.079	22.128	26.554
Yearly Project Revenue	m$		4.575	9.047	3.457	5.049	4.426
Expenses		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Company Expenses	m$	-	3.984	12.183	15.805	20.814	25.305
Yearly Company Expenses	m$		3.984	8.199	3.622	5.009	4.491
Total Project Expenses	m$	-	3.921	11.760	14.815	19.311	23.259
Yearly Project Expenses	m$		3.921	7.839	3.055	4.496	3.948

Total General & Administrative Expenses	m$	-	63	211	314	435	550
Yearly G&A Expenses	m$		63	148	103	122	115
Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Gross Profit	m$		654	1.208	402	553	478
Total Gross Profit	m$	-	654	1.862	2.264	2.817	3.294
Gross Profit Margin	%	-	13	12	11	11	11
Yearly Net Profit	m$		721	1.061	301	430	363
Total Net Profit	m$	-	721	1.782	2.082	2.513	2.876
Net Profit Margin	%	-	11	8	8	7	7
Project Portfolio		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Targeted Projects	Projects	13	19	15	16	15	15
Yearly Total Newly Awarded Projects	Projects	6	13	6	9	8	8
Total Completed Projects	Projects	0	8	14	24	32	40
Total Ongoing Projects	Projects	15	13	20	16	17	16
Tendering Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Tendering Performance	%	45%	72%	39%	55%	50%	52%
Attractiveness of International Construction Market	-	1,5	1,5	1,5	1,5	1,5	1,5
Attractiveness of National Construction Market	-	1,3	1,3	1,3	1,3	1,3	1,3
R/C: Competitive Advantage		4,6	4,5	4,5	4,5	4,5	4,5
International Projects		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of International Projects	Projects	10,0	17,0	15,0	16,0	15,0	15,0
Newly Awarded International Projects	Projects		6,0	13,0	6,0	9,0	8,0
Completed International Projects	Projects	-	5,0	10,0	19,0	27,0	35,0
National Projects Completion Rate		**Initial**	**1**	**2**	**3**	**4**	**5**

Targeted Number of National Projects	Projects	3	1	1	-	-	-
Newly Awarded National Projects	Projects		-	-	-	-	-
Completed National Projects	Projects	-	3	4	4	5	5
Cost Management Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Realized Budget	m$	-	1.125	3.085	7.386	11.007	14.969
Total Earned Budget for Work Performed	m$	-	1.015	2.861	6.804	10.298	13.973
Total Estimated Cost to Complete	m$	2.250	4.031	8.825	7.825	8.633	8.729
Total Cost Variation	m$	-	110	224	582	709	996
Cost Overrun (%)	%	0%	10%	7%	8%	6%	7%
Facilities and Accidents		**Initial**	**1**	**2**	**3**	**4**	**5**
Number of Fatalities	Employees	-	-	-	-	-	-
Number of Accidents	Employees	6	14	14	14	14	14
Total Employees		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Number of Employees	Employees	30.375	26.300	40.662	33.032	34.450	32.902
Total Number of Employee Hires	Employees	11.200	27.075	11.933	17.452	15.293	16.208
Total Number of Employee Exists	Employees	15.287	12.709	19.573	16.041	16.846	16.190

Table 103: Key Outputs of Strategic Options Testing / Strategy 3

Strategy 3							
Key Outputs	**Unit**	**Simulation Year**					
Contract Markup and Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Contract Profit Margin	%	10,3%	10,3%	10,3%	10,3%	10,3%	10,3%
Project Budgets		**Initial**	**1**	**2**	**3**	**4**	**5**

Yearly Total Budget of Newly Awarded Projects	m$		1.572	4.496	2.788	3.097	3.036
Targeted Budget of Potential National Projects	Projects	99	101	103	103	103	103
Targeted Budget of Potential International Projects	Projects	408	416	421	422	422	422
Revenues		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Shareholder Revenue	m$	-	3.307	10.056	13.633	17.563	21.434
Yearly Shareholder Revenue	m$		3.307	6.750	3.577	3.930	3.871
Total Project Revenue	m$	-	3.191	9.802	13.076	16.708	20.267
Yearly Project Revenue	m$		3.191	6.611	3.274	3.632	3.559
Expenses		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Company Expenses	m$	-	2.741	8.750	12.079	15.806	19.498
Yearly Company Expenses	m$		2.741	6.008	3.329	3.727	3.692
Total Project Expenses	m$	-	2.697	8.456	11.386	14.717	17.999
Yearly Project Expenses	m$		2.697	5.760	2.930	3.330	3.282
Total General & Administrative Expenses	m$	-	45	148	231	319	408
Yearly G&A Expenses	m$		45	103	83	88	88
Profit Margin		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Gross Profit	m$		495	852	344	301	277
Total Gross Profit	m$	-	495	1.346	1.690	1.991	2.268
Gross Profit Margin	%	-	13	10	8	8	7
Yearly Net Profit	m$		565	742	248	203	179
Total Net Profit	m$	-	565	1.307	1.555	1.757	1.936
Net Profit Margin	%	-	11	7	5	5	4
Project Portfolio		**Initial**	**1**	**2**	**3**	**4**	**5**
Yearly Total Targeted Projects	Projects	13	19	16	16	16	16

Yearly Total Newly Awarded Projects	Projects	4	11	7	7	7	7
Total Completed Projects	Projects	0	8	13	21	29	36
Total Ongoing Projects	Projects	15	11	16	15	15	15
Tendering Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Tendering Performance	%	31%	56%	41%	45%	45%	45%
Attractiveness of International Construction Market	-	1,5	1,5	1,5	1,5	1,5	1,5
Attractiveness of National Construction Market	-	1,3	1,3	1,3	1,3	1,3	1,3
R/C: Competitive Advantage		2,9	3,0	3,1	3,1	3,1	3,1
International Projects		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of International Projects	Projects	10,0	18,0	16,0	16,0	16,0	16,0
Newly Awarded International Projects	Projects		4,0	11,0	7,0	7,0	7,0
Completed International Projects	Projects	-	5,0	9,0	17,0	24,0	31,0
National Projects Completion Rate		**Initial**	**1**	**2**	**3**	**4**	**5**
Targeted Number of National Projects	Projects	3	1	1	-	-	-
Newly Awarded National Projects	Projects		-	-	-	-	-
Completed National Projects	Projects	-	3	4	4	5	5
Cost Management Performance		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Realized Budget	m$	-	1.125	2.473	5.395	8.250	11.227
Total Earned Budget for Work Performed	m$	-	986	2.190	4.695	7.264	9.835
Total Estimated Cost to Complete	m$	2.250	2.836	6.127	6.411	6.938	7.404
Total Cost Variation	m$	-	139	283	700	986	1.392
Cost Overrun (%)	%	0%	12%	12%	13%	12%	12%
Facilities and Accidents		**Initial**	**1**	**2**	**3**	**4**	**5**
Number of Fatalities	Employees	-	-	-	-	-	-

Number of Accidents	Employees	-	-	-	-	-	-
Total Employees		**Initial**	**1**	**2**	**3**	**4**	**5**
Total Number of Employees	Employees	30.375	22.797	33.044	29.803	29.622	29.234
Total Number of Employee Hires	Employees	7.700	21.597	13.233	14.672	14.375	14.430
Total Number of Employee Exists	Employees	15.290	11.359	16.480	14.858	14.767	14.572

APPENDIX 14: RISKS FACED DURING GROUP MODEL BUILDING SESSIONS

Table 104: Risks faced Group Model Building Sessions

	Risk Occurrence in Sessions							
Definition of Risks	1: Scenario Analysis Workshop	2: Strategy Mapping Workshop	3: KPI Selection Interviews	4: Scorecard Building Workshop	5: Model Assumptions Workshop	6: Face Validity Workshop	7: Scenario Testing	8: Strategic Options Testing
Risk 1. Difficulties in achieving a consensus on three scenarios	**x**							
Risk 2. Reliance on judgements and opinions of dominant participant	**x**	**x**		**x**	**x**			
Risk 3. Excessive time to get participants used to and familiarize with future thinking	**x**							
Risk 4. Concerns of participants to share their opinion with others	**x**							
Risk 5. Difficulty in developing a shared understanding of future thinking due to individual biases	**x**							
Risk 6. Difficulties in achieving a consensus on strategic objectives		**x**						
Risk 7. Excessive time to review and discuss Strategic Objectives Taxonomy		**x**						
Risk 8. Difficulties in conducting and adapting "strategic thinking", tendency to focus on "operational" details		**x**						

Risk 9. Difficulties in achieving a consensus on interdependencies among strategic objectives		**x**						
Risk 10. Difficulty in prioritizing and defining causalities among strategic objectives		**x**						
Risk 11. Belief about each strategic objective is so important and eventually effect each other		**x**						
Risk 12. Excessive time to get participants used to and familiarize with the underlying theory of strategy maps		**x**						
Risk 13: Difficulties in understanding some KPIs, especially those that are not utilized previously in the organization			**x**					
Risk 14: Difficulties in ranking KPIS in terms of simplicity and measurability, especially when participants are unfamiliar with the associated KPI			**x**					
Risk 15: Difficulties in gaining consensus on rankings of KPI attributes			**x**					
Risk 16: Difficulties in prioritizing KPIs and selecting the final list			**x**					
Risk 17: Unwillingness of participants to share their opinion, while compared with sessions those held with the top management			**x**					
Risk 18: Facing with scope creeps in session due to various questions of participants			**x**					
Risk 19: Difficulties in gaining consensus on factors selected and causalities developed in Conceptual Model				**x**				

Risk 20: Difficulty in adapting systems thinking and causal mapping				x				
Risk 21: Difficulties in gaining consensus on the model assumptions					x			
Risk 22: Rejecting the idea of "assuming something", and claiming to have objective roots for each assumption					x			
Risk 23: Expecting from the Computerized Model to "solve everything"					x			
Risk 24: Difficulties in adapting "systems thinking", difficulties in understanding model formulations and "Stella Architecture", despite the training session					x	x	x	x
Risk 25: Difficulties in assigning initial values, especially those that require subjective judgements					x		x	x
Risk 26: Difficulties in interpreting the model outputs, not trusting the simulation results						x	x	x
Risk 27: Confusion in comparing simulation results and real-life behavior as the model gives predictive results about future						x	x	x

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ACHIEVEMENTS

(1) MSc, METU Graduate Courses Performance Awards, 2012

(2) BSc, METU High Honor Student

(3) SAN-TEZ Project sponsored by Ministry of Science, Industry and Technology