SOURCES AND DETERMINANTS OF INTRA-INDUSTRY HETEROGENEITY IN THE INNOVATION PROCESS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

ALP EREN YURTSEVEN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
THE DEPARTMENT OF SCIENCE AND TECHNOLOGY POLICY STUDIES

SEPTEMBER 2015

Approval of the Graduate School of Social Sciences

Prof. Dr. Meliha Altunışık
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy

Prof. Dr. M. Teoman Pamukçu
Head of Department

This is to certify that we have read this thesis and in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.

Prof. Dr. M. Teoman Pamukçu
Supervisor

Examining Committee Members

Prof. Dr. Erkan Erdil	(METU, ECON)	
Prof. Dr. M. Teoman Pamukçu	(METU, STPS)	
Prof. Dr. Erol Taymaz	(METU, ECON)	
Assist. Prof. Dr. İ Semih Akçomak	(METU, STPS)	
Assoc. Prof. Dr. Seyit M. Cilasun	(ATILIM, ECON)	

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name : Alp Eren Yurtseven

Signature :

ABSTRACT

SOURCES AND DETERMINANTS OF INTRA-INDUSTRY HETEROGENEITY IN THE INNOVATION PROCESS

YURTSEVEN, Alp Eren
PhD, Science and Technology Policy Studies
Supervisor: Prof. Dr. M. Teoman Pamukçu

September 2015, 289 pages

This thesis aims to explore the sources of intra – industry heterogeneity of innovation modes and the effects of such heterogeneity on the innovation process. A taxonomy of innovative firms was constructed and different modes of innovation were explored for this purpose, then micro and macro level determinants of intra – industry heterogeneity were analyzed. The linkage between firm's innovative characteristics and its resource position, knowledge base and relationships with other organizations was established. Finally the effects of intra – industry heterogeneity on the innovation process were investigated using a modified version of the Crépon – Duguet – Mairesse model.

Analysis results indicate that there are groups of firms within the same sector that display distinct innovation characteristics and firm's resource position, knowledge base and cooperation behavior have a bearing on the innovative characteristics of firms. Furthermore, it was found that variables related to variety generation within a sector increase heterogeneity; whereas increasing average firm size or concentration of firms that belong to a group reduces the amount of heterogeneity in that sector. Research findings indicate that firms operating in more diverse sectors (in terms of innovative behavior) spend more on innovation and introduce product innovations more efficiently.

Research based evidence from this thesis show that sectors are populated with firms that have distinct innovative characteristics. Therefore, sectoral innovation policies should target specific groups, rather than emphasizing innovation typologies based on vague abstractions. Moreover heterogeneity of innovative behavior can be regarded as a risk – mitigation tool to control the adverse effects of path dependency and lock – in.

Keywords : innovation modes, intra – industry heterogeneity, firm taxonomy

ÖZ

YENİLİK SÜRECİNDE SEKTÖR İÇİ ÇEŞİTLİLİĞİN KAYNAKLARI VE BELİRLEYİCİ ETMENLERİ

YURTSEVEN, Alp Eren
Doktora, Bilim ve Teknoloji Politikası Çalışmaları
Tez Yöneticisi: Prof. Dr. M. Teoman Pamukçu

Eylül 2015, 289 sayfa

Bu tez sektör içi yenilik modu çeşitliğinin kaynakları ve bu çeşitliliğin yenilik süreci üzerindeki etkilerinin araştırılmasını amaçlamaktadır. Bu amaçla yenilikçi firmaların bir taksonomisini oluşturulmuş ve farklı inovasyon modları araştırılmıştır, daha sonra sektör içi çeşitliliğin mikro ve makro seviyedeki kaynakları analiz edilmiştir. Firmanın yenilik karakteristikleri ile kaynak pozisyonu, bilgi tabanı ve diğer organizasyonlarla ilişkisi arasında bir bağ oluşturulmuştur. Sektör içi çeşitliliğin kaynakları regresyon ağacı ve sabit etki modelleri ile incelenmiştir. Son olarak sektör içi çeşitliliğin yenilik sürecindeki etkileri Crépon – Duguet – Mairesse modelinin değiştirilmiş bir versiyonu ile araştırılmıştır.

Analiz sonuçları aynı sektör içinde farklı yenilik özellikleri olan firma grupları olduğunu göstermektedir. Ayrıca aynı sektör içindeki firmalar farklı yenilik stratejileri izleseler de, yenilik aktivitelerinde bazı örüntüler de görülmektedir. Sınıflama ağacı analizi sonuçları firmanın kaynak pozisyonu, bilgi tabanı ve

işbirliği davranışlarının yenilikçi özellikleri üzerinde etkili olduğunu göstermektedir.

Regresyon ağacı ve sabit etki panel modeli kestirimleri, sektör içinde farklılık yaratımıyla ilgili değişkenlerin çeşitliliği artırdığını göstermektedir. Diğer taraftan artan firma büyüklüğü ya da gruba bağlı firma yoğunluğu o sektör içindeki çeşitliliği düşürmektedir.

Araştırma bulgularına dayanarak çeşitlilik yönünden zengin sektörlerde faaliyet gösteren firmaların daha fazla yenilik harcaması yaptığı ve ürün yeniliklerini daha verimli biçimde piyasaya sürebildikleri söylenebilir.

Bu tezden elde edilen araştırmaya dayalı kanıtlar sektörlerin farklı yenilik karakteristikleri olan firmalardan oluştuğunu göstermektedir. Bu nedenle sektörel yenilik politikaları muğlak soyutlamalara dayanan yenilik tipleri yerine belirli grupları hedeflemelidir. Ayrıca yenilik davranışlarındaki çeşitlilik patika bağımlığı ve kilitlenmenin olumsuz etkilerini kontrol etmek için bir risk azaltma aracı olarak da görülebilir.

Anahtar kelimeler : yenilik modları, sektör içi çeşitlilik, firma sınıflandırması

To my beloved son Kerem Alp Yurtseven

ACKNOWLEDGEMENTS

I would like to thank my thesis supervisor Prof. Dr. Teoman Pamukçu for his invaluable counselling. I appreciatively acknowledge the constructive critics and recommendations from Prof. Dr. Erkan Erdil, Prof. Dr. Erol Taymaz, Assist. Prof. Dr. Semih Akçomak and Assoc. Prof. Dr. Seyit Cilasun. This thesis could not have been completed without their guidance.

I would like to extend my thanks to Dr. Sinan Tandoğan for his encouragement.

I also would like to thank Turkish Statistical Institute for providing the data used in this thesis and their assistance.

I am sincerely grateful to my parents Mehtap and Sedat Yurtseven for always being there for me.

Finally I would like to thank my wife Berna Yurtseven for her support and understanding.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

CHAPTER 1

INTRODUCTION

Keeling Islands are located in the Indian Ocean between Australia and Sri Lanka. Two atolls and twenty seven islands constitute the territory of Keeling Islands. Terrestrial fauna and flora of the territory is rather depauperate (i.e. poor in variety of species), whereas the diversity[1] of organisms in the ocean surrounding the coral reefs is comparable to that of rain forests. On 4th of April 1836, Charles Darwin was standing on the shores of one of the islands, amazed by the richness of the fauna dependent on marine resources and the sharp contrast between the diversity observed on the islands and in the seawater contained within the walls of coral reefs. His observations on the different degrees of diversity on the Keeling Islands paved the way for his ground breaking work "The Origin of Species"[2].

As different ecosystems within a spatial proximity may display varying degrees of diversity, different innovation patterns may co – exist within sectors. Moreover, heterogeneity stemming from co – existence of distinct modes of innovation may vary across sectors. In this context, analysis of heterogeneous innovation patterns bears both theoretical and practical significance. From an evolutionary point of view, heterogeneity results from the interplay between variation and selection; hence this thesis aims to contribute to the existing

[1] Diversity and heterogeneity are used interchangeably throughout the thesis.

[2] Original title for the first edition in 1859 is "On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life". For the sixth edition of 1872, the short title was changed to "The Origin of Species"

literature in two ways. First, a novel evolutionary framework is put forward to analyze the micro and macro level determinants of heterogeneity within sectors. Second, a versatile set of numerical methods are used to gather empirical evidence to verify this framework. On the other hand, this theoretical framework and gathered empirical evidence can be translated into the practical domain. Diversification is a powerful risk mitigation tool, which is commonly employed in portfolio management and energy planning. Consequently, empirical evidence pertaining to the heterogeneity of innovative behavior within sectors can be used to formulate policies that benefit from diversity of innovation patterns to assure sustainability of innovation systems.

"The Origin of Species" has been the source of endless debates, yet Charles Darwin's contribution is very exceptional since his views have not only paved the way for modern biology but also deeply influenced various domains in social sciences including economy. In fact, Charles Darwin himself was much inspired by the economists of his era such as Thomas Malthus and Herbert Spencer. Although the direction of causality is unclear, one thing is for sure that the main building blocks of modern evolutionary biology, i.e. variation, selection and retention, are also extensively used in contemporary evolutionary economics. In this framework, a population consists of selection units with varying characteristics. Selection mechanisms operate on these characteristics, virtually creating a *fitness score,* which can alter the relative importance of selection units.

In this sense, all the mechanisms that differentially select or selectively favor certain variations in the economic domain are analogous to natural selection in evolutionary biology. Using biological analogies, it can be argued that certain performance indicators, such as profitability of a firm, are related to its *fitness* and only firms with superior performance (e.g. profitable firms) can survive upon *selection*, which may lead to a homogeneous profit maximization behavior.

Hence it can be assumed that selection reduces heterogeneity, leading to the convergence of firm goals.

Similar technological capabilities, financial incentives and constraints may shape common paths for firms. These regularities, as characterized in the concept of technological regimes by Nelson and Winter (1982), may direct the firms to organize their innovative activities in resembling ways. According to Winter (1984) technological regimes define the key features of a knowledge domain with respect to imitability of technology, number of knowledge bases pertaining to a specific production method, amount of resources committed to a typical project.

Sectoral innovation system approach depends on the idea that firms nested in a sector behave in correlated ways since they share sources of information and technology and perceive similar incentives for innovation (Malerba & Orsenigo, 1996; Malerba, 2005). However there are several empirical studies indicating that differential performance of firms in terms of profitability is attributable to firm specific characteristics rather than sectoral affiliation (Rumelt, 1991; Powell, 1996).

Dosi (2005) reports persisting heterogeneity across firms notwithstanding the competitive process. Griliches and Mairesse (1995) also address the need for a richer theoretical framework, which can better explain the heterogeneity of firms within the same line of business.

It can be argued that diversity provides the raw material for natural selection. As shall be discussed in detail throughout the thesis, selection does not always lead to an optimum solution. However this process may yield a better outcome if it operates in a more diverse environment. Expected improvement in fitness is increased with the amount of variability upon which selection acts. Depending on the unit of selection, diversity of actors, technologies, institutions should always be an important element of an evolutionary framework.

Some degree of diversity in the innovative behavior of firms shall always be observed in all sectors, regardless of the level of aggregation. Since the diversity of innovative behavior within a sector is permanent, its sources and effects on the innovative performance call for a detailed investigation. Strategic management literature provides a rich discussion on the differential performance of firms in the same line of business (Nelson, 1991; Barney 1991; Dierickx and Cool 1989; Peteraf 1993; Teece et. al., 1997). However, the resource based theory of the firm states that firms need valuable resources and capabilities in order to attain competitiveness. On the other hand, firms succeed in competition because of their valuable resources. Both these statements constitute a circular reasoning, since they explain everything or nothing at the same time.

One of the distinguishing features of evolutionary economics is appreciative theorizing based upon empirical studies (Fagerberg, 2003). Therefore, the dynamics of intra-industry heterogeneity in terms of innovative behavior and the effects of this heterogeneity on economic performance should be empirically identified. This thesis aims to contribute to existing literature on evolutionary economics by identifying different innovation patterns and exploring mechanisms that affect the diversity of such patterns within industries.

In addition to its scholar contribution, this thesis also aims to put forward an innovation policy framework with the concept of diversity at its core. Embedding diversity in the policy making process is expected to enhance its efficiency and quality in a number of ways. First, exploration of heterogeneous innovation patterns requires a thorough analysis of the innovation landscape and identifying different characteristics of actors within the system. Consequently, active participation of all relevant actors can be assured and policies can be built on a broader phase. Policies that are shaped by specific interests of a limited influence group may become more rigid in time due to self – reinforcement and lock – in; whereas broadening the base policy base in the inception phase may circumvent the path – dependency related risks. Second, a diversified innovation system is expected to be robust against shocks. Policies that acknowledge and deliberately foster diversity of innovation practices may provide long – term sustainability.

1.1 Research Questions

Building upon the existing literature and research aims outlined above, the main endeavor of this thesis is to empirically measure the degree of heterogeneity of innovative behavior within sectors, distinguishing between various aspects of heterogeneity. Another objective of this study is to investigate the relevance of this heterogeneity to innovative performance. Given these objectives, research questions handled in this study are as follows:

- Is it possible to construct a taxonomy of firms based on their innovative characteristics?
- Are there common modes of innovation amongst firms?
- Is it possible to quantify the diversity of innovative behavior within a sector?
- How does the resource and knowledge base of the firm affect its innovative characteristics?
- What are the parameters that influence the amount of intra – industry heterogeneity within a sector?
- How does the amount of intra-industry heterogeneity affect the innovative performance of firms?

1.2 Research Significance

This thesis aims to put forward an evolutionary framework to analyze the sources and determinants of intra – industry heterogeneity, verify this framework with numerical methods, and propose an innovation policy framework after a careful analysis of obtained research findings. In this context, this study is expected to contribute to the existing literature first by identifying modes of innovation and forming a taxonomy of innovative firms in manufacturing and service sectors in Turkey. Previous studies (Leiponen and Drejer, 2007; Srholec and Verspagen, 2008; Yurtseven and Tandoğan, 2012) use cross section data for this purpose, whereas this study adds a temporal dimension to such analysis by merging three innovation surveys pertaining to different periods. Foster and Metcalfe (2001) state that the central issue in evolutionary economics is not being but becoming, i.e. one should try to explain why the world changes the way it does with respect to change and direction. Analysis results obtained from longitudinal data are expected to yield a better description of industrial dynamics.

Articles cited above provide enough evidence for substantial intra-industry heterogeneity in terms of innovative behavior, but offer no empirical measure to assess the extent of diversity observed within industries. Diversity is a multi-dimensional concept, composed of several elements. Therefore, different aspects of intra-industry heterogeneity should be explored. This thesis employs two distinct heterogeneity measures in order to capture the dynamics of intra-industry heterogeneity and its effects on economic performance.

As shall be discussed in Chapter 3, empirical methodology adopted in this thesis is compatible with OECD's Innovation Microdata Project; hence obtained results can be compared with other OECD countries. Latent class analysis and recursive partitioning methods are frequently used in machine learning problems. From a methodological point of view, application of these techniques for the analysis of dynamics of innovation is a novelty of this thesis.

1.3 Organization of the Thesis

The rest of this text is organized as follows. Next chapter puts forward the theoretical framework of this thesis from both evolutionary and strategic management perspectives. Economic aspects related to diversity are also elucidated in the following chapter. A synthesis of evolutionary economics and strategic management literature is given and research questions listed above are developed into concrete research objectives.

Empirical framework of this thesis is outlined in Chapter 3. Discussion in this chapter starts with the basics of classification followed by a literature review of empirical studies about the classification of industries and firms. A comparison of various multivariate statistical techniques that can be used for classificatory purposes and pattern identification is given within the scope of research objectives set in Chapter 2. In the next section, various aspects of the concept of heterogeneity are elaborated and metrics to quantify heterogeneity are introduced. The relationship between innovation and productivity is also summarized in this chapter. Chapter 3 continues with description of the data set used in the empirical analysis. Mapping of the theoretical background to the application domain is also provided in this section.

Results of the latent class analysis to form the taxonomy of innovative firms in Turkey are given in Chapter 4. Factor analysis pertaining to latent modes of innovation is also reported in this chapter. Findings from the classification and factor analysis are compared to results of the OECD Innovation Microdata Project.

Sources and determinants of intra – industry heterogeneity of innovative behavior are analyzed in Chapter 5. Firm level determinants of diverse innovative behavior are examined with a classification tree model. Calculated heterogeneity indices are introduced followed by the regression tree analysis and fixed effects time series estimations, which were conducted to identify the sector level factors that affect intra-industry heterogeneity.
Estimation results pertaining to the innovation – productivity relationship and the effects of intra – industry heterogeneity on the innovation process are presented in Chapter 6.

A novel policy framework with the concept of diversity embedded in its core is put forward in Chapter 7. Relationship between diversity and the notion of robustness, which is commonly used in physics and biology, is elaborated in this chapter. Moreover, the merits of using diversification as a risk – mitigation tool especially in contexts characterized by uncertainty are discussed. This chapter is concluded with solid policy recommendations that are based on research findings reported in this thesis.

Chapter 8 sums up the research findings and policy recommendations put forward in this thesis. Research limitations of this thesis and directions for future research are also given in this chapter.

CHAPTER 2

THEORETICAL FRAMEWORK

2.1 Sources of Heterogeneity from an Evolutionary Perspective

An evolutionary framework should be able to explain the changing patterns of co-existence between entities within a population. As outlined in the first chapter, this thesis aims to empirically measure the degree of heterogeneity of innovative behavior within sectors, which requires clustering of firms according to their related aspects. Inevitably evolutionary analogies are used in both model construction and interpretation of results. Following subsections provide a summary of different strands in evolutionary economics, with specific emphasis on the Lamarckian vs Darwinian notions of evolution. This distinction is elaborated in order to put forward the ontological stance of this thesis.

2.1.1 Early Developments in Evolutionary Economics

When neoclassical economics emerged in the second half of the 19th century, it was mainly inspired by physics. However this focus shifted towards biology and biological metaphors were extensively used in social sciences from late 19th century to the beginning of the 1st World War. This spark of interest vanished during the period 1920 and 1950. Armen Alchian's famous study, which was published in 1950, brought back evolutionary concepts to the social science domain once again. Nelson and Winter's seminal work, which was published in 1982, marked the beginning of a new era in the field of evolutionary economics.

It should be noted that this simplified chronology does not represent the gradual development of a cohesive theory. On the contrary, evolutionary economics today is quite eclectic and accommodates conflicting views. A graphical representation of the “evolution”[3] of evolutionary economics is presented in Figure 1.

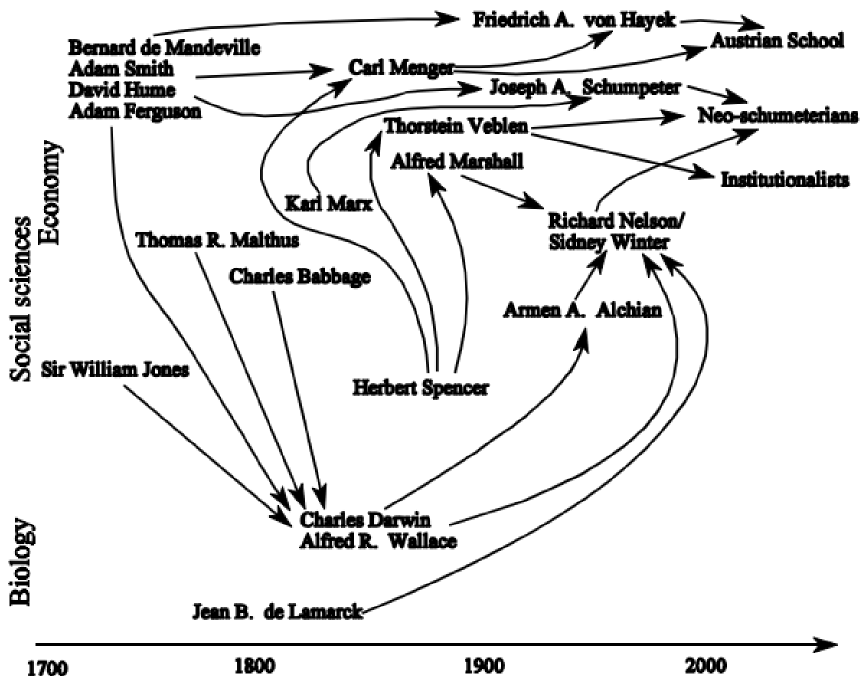


Figure 1 Different strands in evolutionary economics (Kwasnicki, 1996)

Classical economists had provided significant insight about diversity and its role in the socio – economic domain; even before the evolutionary debates. For example Adam Smith focuses on the relationship between the level of division of labor and diversity and variety of goods and services (Knell, 2008). According to Loasby (1999, p. 57), Adam Smith’s interpretation corresponds to the development of differentiated knowledge; hence a set of idiosyncratic and diverse competences.

[3]Evolution is often used as a synonym for development, growth, progress or advancement.

Charles Darwin's contribution was not only a major leap in life sciences but it also had a deep effect on social sciences including economics, sociology, anthropology and psychology. Although evolutionary line of thinking is largely attributed to Charles Darwin, the first cohesive theory of evolution was put forward by Jean Baptiste Lamarck, who is known for his theory of inheritance of acquired characteristics.

Lamarckian theory suggests that an organism can pass on traits it acquired during lifetime to its offspring. Accordingly, organisms loose characteristics they do not require or they develop useful traits. For example Lamarckian view suggests that giraffes, which continuously extend their necks to reach leaves in high trees, strengthen and gradually lengthen their necks.

According to Stocking (1962), proponents of the social evolutionism in the late 19th century (including Lewis Henry Morgan and Henry Spencer) relied on the Lamarckian view of "soft inheritance" to establish the linkage between intellectual progress and organic development of mind. Herbert Spencer, who developed his theories from an individualistic conservative political stance, was a prominent advocate of Lamarckism in the domains of both biology and social sciences.

Spencer aimed to develop a universal theory of evolution and a complete philosophical synthesis. Application of Spencer's conception to societies indicates that societies start from a simplistic organizational structure, which is rather homogenous. Complexity of the social structure increases with advancement until it reaches an equilibrium.

Although the term "survival of the fittest" was first used by Herbert Spencer, his views were discredited for the favor of Charles Darwin, who is widely recognized as the founding father of evolutionary line of thinking. Spencer's work is overlooked not because of his extrapolations of political implications from his theories but due to overall dislike related to his conservative individualistic stance. Moreover Spencer's struggle to establish his theory on Lamarckism grounds failed, since developments in genetics falsified inheritance of acquired characteristics (Roark, 2004).

Alfred Marshall is another eminent 19th century figure, who attempted to adopt biological concepts to the social domain. Marshall realized that mechanical interpretations of economic activity provided limited analysis capability; hence embraced biology in order to develop more fertile metaphors. Darwinian interpretation of evolution was neither popular nor dominant by the end of 19th century. Therefore, Marshall's intellectual partiality was aligned with Spencer rather than that of Darwin (Hodgson, 2007). Marshall is well known for his often quoted remark "Mecca of the economist lies in economic biology rather than economic dynamics". Although Marshall used this famous quotation in the preface of *Principles of Economics* from the fifth edition on, he did not put forward a cohesive theory, which uses evolutionary metaphors to explain the development of social institutions and technological change (Hodgson, 2005). Instead, Marshall focused on short period and long period equilibrium of an industry. Accordingly, short period normal prices refer to less than a year, and long period normal prices, which include capital goods, pertain to several years ahead. In Marshall's conception, firms can modify their long term productive capacities according to short term price signals. Marshall introduced the notion of representative firm in order to cope with problems related to growth of firms and knowledge in the long period (Knell, 2008). It can be argued that introduction of the representative firm also means acknowledging the vast heterogeneity within an industry; but it also means that size, behavior and profit rates of firms in an industry should converge to similar levels in the long period (Opocher & Steedman, 2008). According to Moss (1984), Marshall's equilibrium models are inconsistent with the existence of heterogeneous economic agents.

Darwinian notion of evolution focuses on analyzing sequential developments with causal explanations, which are based on processual algorithms that alter the initial state of an entity upon execution of some decision rules. Hodgson (2006, p. 22) defines natural selection as a processual algorithm since it transforms populations based on the fitness of individuals embodied in them. Therefore, dynamics of complex and evolving systems observed in biological and socio-economic domains can be explained with sequential accumulation of causal mechanisms (Hodgson, 2002; 2004). Divine and miraculous causes are exceptional and each sequence of change in nature should have a causal explanation. In this sense path dependency may be defined as dependence on initial conditions, or recurring emergence of initial conditions, resulting relative permanency of particular habits. Path dependence may have four related causes. Increasing returns, self-reinforcement, positive feedbacks, which may also be referred to as cumulative causations and lock-in. With positive feedbacks, an action or choice creates positive externalities when that same choice is made by other agents. The effect of a positive feedback loop is not necessarily positive in the sense of being desirable. Positive refers to the direction of change rather than the desirability of the outcome. The negative feedback loop tends to reduce or inhibit a process, while the positive feedback loop tends to expand or promote it.

Veblen tries to explain the dynamic socio-economic processes with the Darwinian causality principle. According to Hodgson (1998), Veblen was very much influenced by Herbert Spencer, whom Hodgson describes as a "Lamarckian biological reductionist". However, Veblen (1898) defines evolution as "a theory of unfolding sequence" (p. 375), "the orderly unfolding development of fact" (p. 376), "the theory of a developmental relationship" (p. 376) and "the concept of dispassionate cumulative causation" (p. 381). Propensity patterns of agents are subjected to natural selection and their development over time should be explained by the principle of causality.

Veblen defines instinct as a habit, which has very strong decisiveness (Sherman, 2003). In this sense, selection process operates on habits. Habits, which are derived from instincts, continuously interact with institutions. This interplay is reflected in the following quote (Veblen, 1898, p. 391):

> *The economic life history of the individual is a cumulative process of adaptation of means to ends that cumulatively change as the process goes on, both the agent and his environment being at any point the outcome of the past process.*

Darwinian notion of evolution resides in the very core of Veblen's work, although his description of societal change follows a Lamarckian scheme. According to Veblen, cultural development is a cumulative permutation of habits. Therefore, it can be argued that Veblen used a Darwinian notion at the individual level, and opted for a Lamarckian interpretation at the societal level (Reinert, 2006).

Karl Marx's theory of social change and the Darwinian notion of evolution are slightly correlated. For example the shift from crude designs to more refined manufacturing systems is given as a proof of technological evolution. Similarly, inferior social and economic systems such as feudalism, which are handicapped with their internal inconsistencies and inefficiencies, would have to be replaced by more sophisticated systems over the course of history. On the other hand, Marxist analysis of social change and technological development benefits from biological metaphors as well (Clark & Juma, 1988).

2.1.2 Contemporary Evolutionary Economics

As has been summarized in the previous section, evolutionary line of thinking in economics can be traced back to the contributions of Alfred Marshall, Thorstein Veblen, Nicholas Georgescu – Roegen, Friedrich Hayek and Joseph Schumpeter. However these loosely related evolutionary strands were synthesized in Nelson and Winter's (1982) seminal work *An Evolutionary Theory of Economic Change*. Contemporary evolutionary economics is often termed as "neo – Schumpeterian" for embracing Schumpeter's dynamic view of economic processes characterized by discontinuities and constant change. In fact Nelson and Winter (1982; 39) label their evolutionary approach as "neo-Schumpeterian". According to Witt (2008) Nelson and Winter's methodology accommodates a dualistic evolutionary view such that biological and socio-economic evolutions constitute two distinct processes of reality, i.e. generalizations derived from one domain cannot be directly applied to another. Nelson and Winter (1982; p. 18) abstract industries as population of firms and their main interest is to explain the development characteristics of industries. Their analysis of the firm does not aim to forge a new theory of the firm, but it is restricted to their explanation of the development of industries. Accordingly, firms are taken as goal driven and purposefully behaving entities. Firms actively seek new methods to adapt to changing environmental conditions. They can acquire new skills and attributes through internal development. Influenced by the behavioral theories of the firm, Nelson and Winter embrace the idea of limited (or bounded) rationality. Therefore, firms are assumed to be profit seeking (instead of profit maximizing) organizations (Winter, 1988, p. 174). Nelson and Winter's interpretation of economic evolution slightly contradicts Darwinian notion of evolution; since firms are regarded as repositories of productive knowledge or experience and knowledge based organizations capable of learning (Winter, 1988, p. 175). Therefore, Nelson and Winter's notion of evolution has a Lamarckian essence, since firms can develop new characteristics by purposeful actions and learning. It is apparent that Nelson and Winter pragmatically use biological metaphors to explain the dynamics of complex social systems, but do not adhere to a theory (i.e. Universal or Generalized Darwinism, see below). On the other hand, the theoretical framework that is mainly put forward by Geoffrey Hodgson aims to depict and analyze the dynamics of economic change with the generalized Darwinian principles of selection, variation and retention (Hodgson, 2002; Hodgson &

Knudsen, 2006; Aldrich, ve diğerleri, 2008). Accordingly the Universal Darwinism framework proposes the following basic statements:

- Social sciences (without any exception) should focus on “detailed, cumulative, causal explanations” rather than functional “just so stories” (Hodgson, 2002). For example history should focus on the causal relationships between events rather than chronologically listing and describing them.
- All evolutionary processes both in the natural and social domains share the same basic ontological structure, which can be abstracted as the Darwinian scheme of the interaction between variation, selection and retention. In this context, “evolutionary processes” refer to the dynamics of complex systems, which involve populations of heterogeneous agents that are causally related to each other.

Hodgson and Knudsen (2006, p.13) provide a rather broad definition of “Darwinism” as the “causal theory of evolution in complex population systems involving the inheritance of generative instructions by individual units and a process of selection of the varied population of such entities”. According to Rahmeyer (2010) the perceived distinction between Darwinism as a monistic and neo-Schumpeterian evolutionary economics as a dualistic strand is hardly significant. Both strands share the same foundation; however proponents of the neo-Schumpeterian approach are less keen to develop a coherent model in consistence with the Darwinian principles (Witt, 2008). Therefore, Darwinian principles within the context of evolutionary economics are summarized in the following subsections.

2.1.3 Basic Concepts of (Darwinian) Evolution

Evolutionary biology focuses on populations of genotypes and phenotypes. Genotypes can be defined as the matter of genetic inheritance of animate entities. Population of phenotypes includes physical aspects, behavioral patterns or responses to particular stimuli. Genotypic characteristics affect phenotypic traits; however environmental conditions, such as climate or abundance of food supply, also influence phenotypic development. Phenotypes are manifested in living organisms, which have a limited life cycle; whereas genes are transferred from one generation to another providing the continuity of the evolutionary system. Combination of existing genes in addition to mutations creates variety in the genotype population. Such mutations also alter phenotypic characteristics since they are coupled with genotypic characteristics as well. On the other hand, selection mechanisms refine the gene pool by reducing the relative frequency of entities bearing phenotypic characteristics, which are not compatible with the selection environment.

It is widely asserted that an evolutionary system should satisfy the following principles (Metcalfe, 2005):

- Principle of variation: Members belonging to a specific population vary with respect to at least one trait that has a selective significance.
- Principle of selection: Some members adapt better to altering conditions or “evolutionary pressure” hence they are able to increase their relative proportion.
- Principle of heredity: Some form of a copying mechanism should exist to ensure the continuity of physical form or behavior of members over time.

Differential growth of a certain entity depends on the characteristics of other competing entities and the conditions that pertain to the selection environment. Therefore, evolutionary change depends on interaction and mutual coordination. Endler and McLellan (1988) identify five distinct processes, which define an evolutionary process:

- Processes that generate variation in the pool of traits by introducing new entities or eliminating existing ones in the population, or altering the attributes of existing entities
- Processes that restrict and guide the possible patterns of variation
- Processes that change the relative frequency of different entities within the population
- Processes that determine the overall rate of change governing these three processes
- Processes that determine the overall direction of evolutionary change

Nelson and Winter (1974) state that the competitive economic environment, in which firms operate, is characterized by struggle and motion. Boundedly rational economic agents do not have the capacity to foresee the future or apprehend the external conditions completely. Indeed firms depend on rules and heuristics in their decision – making process. Consequently, firms develop different traits over time, which may include risk – taking as well as careful and prudent behavior. However it is apparent that these traits are not equally shared by all economic actors. This observation leads to a very essential argument in evolutionary economics stating that economic actors display considerable heterogeneity with respect to their behavior and strategies. Evolutionary theory is distinguished from the neo-classical theory by defining firms as complex and learning organizations, which are capable of developing different solutions to common problems and either themselves or their traits are subjected to selection. In this sense the change observed in a single firm (ontogenetic development) or a sector populated with heterogeneous firms (phylogenetic development) can be explained by the fundamental evolutionary processes of variation, selection and retention.

2.1.3.1 Variation

Firms usually do not seek for something new, unless they are dissatisfied with their economic performance. Moreover the perception of need to adapt to change or new external requirements may also provide the stimulus to search for new methods (Witt, 1996). Consequently, any deviation from already established methods for producing goods and services can be considered as a variation and it is closely related to the concepts of mutation or recombination in nature (Nelson and Winter, 1982). Bounded rationality of economic agents leads to heterogeneous behavior and diverse routines, which in turn propels the evolutionary process (Metcalfe, 1995; Srholec & Verspagen, 2008). As a result it can be argued that firms are learning organizations, which can be characterized with their knowledge base and past experience (Winter, 1988).

Variation can be blind or intentional. As the name implies, blind variations are not planned. They rather stem from accidents, mistakes, learning by doing, imitation or even from idle curiosity (March, 1981). Moreover firms' reactions to shocks or sudden alterations in the external environment may also lead to unplanned variations in the fulfillment of operational processes. On the other hand, intentional variation is a deliberate effort towards creating alternatives to existing routines and seeking solutions to emerging problems. In contrast to blind variation, intentional variation includes a consciousness element, which affects the type of responses to difficult situations and challenges. Formal R&D projects carried out in firms are a major source of intentional variation. Moreover some firms may opt to reserve some creativity time for their employees in order to foster innovation, which may also be considered as a way of creating intentional variation. According to Nelson and Winter (1982, p. 11) blind and intentional variation are mingled and are hard to separate from each other.

The role of blind variations in the innovation process is controversial in the evolutionary economics literature (Foster, 2000). As shall be discussed in more detail in the following sub-section, selection mechanisms operate on the results of variations, not on the intentions on the actors that caused the variation. Consequently, it can be argued that blind variations may as well be as effective as intentional variations in the innovation process (Aldrich & Ruef, 2006). From another perspective, every variation is blind in a sense that its outcome can never be exactly predicted. Therefore, evolutionary economics suggest that specific outcomes cannot be predicted in advance. Hodgson and Knudsen (2006) suppose that outcomes produced by complex systems cannot be determined by a single actor, and the properties of this outcome cannot be attributed to a single entity in a complex system.

Selection mechanisms are neutral to the type and source of variation. However selection mechanisms are not necessarily moral or just. Moreover selection does not essentially lead to optimality or improvement in the former configuration (Hodgson and Knudsen, 2006). In this sense, variation is a necessary but insufficient element of heterogeneity. Selection, which follows variation, is decisive in the occurrence of heterogeneity.

2.1.3.2 Selection

It is generally assumed that while variation results in heterogeneity, another evolutionary process, selection, reduces it simultaneously. In this sense, all the mechanisms that differentially select or selectively favor certain variations in the economic domain are analogous to natural selection in evolutionary biology. Selection rewards strategies that results in higher competitiveness, whereas lagging firms are punished. Nelson (1991) suggests that “winners and losers” of Schumpeter’s creative destruction process are largely determined ex post in the actual competitive contest. Therefore, the relative frequencies of entities in a population are altered by the selection mechanisms, which favor that fit the selection criteria. Formation, adaptation and diffusion of variation change the population, of which entities are subjected to selection. Over time, surviving organizations obtain domination; hence their attributes characterize the population. Firms with better adaptation capability are able to increase their internal capacity and productivity, which in turn enables them to experiment with new variations increasing the selection pressure on the less adapted firms.

Simple biological organisms may abide with the rules and mechanisms of selection. However firms are social entities capable of consciously reacting to external shocks and deliberately interacting with their environment. Therefore, it can be argued that they are less prone to the effects of external selection than biological organisms. Consequently, it can be argued that “internal selection” is more relevant in explaining the variations in social behavior. As manifested in the dynamic capabilities concept (Teece, Pisano, & Shuen, 1997) meta routines act as the main source of identification, selection, exploitation, modification and refusal of firms’ problem solving and adaptive behavior.

The idea of selection being endogenous to the subjects, whom it affects, is countered by the argument that internal and external selection follows the same principles and their difference stems from their reference levels. Som (2012) provides a biological example to explain this difference, suggesting that the struggle for reproduction may create variations (e.g. longer tail feathers), which may be dysfunctional to organism’s general adaptive capability. Although social entities can give intentional responses to external shocks and even anticipate the rate and degree of change, in the end their ideas have to prove themselves under external conditions. It can be argued that biological and socio-economical selection protects well adapted subjects from extinction, whereas they eliminate entities with less adaptive capability (Som, 2012). Consequently, if selection is assumed to be universal, then it is also reasonable to assume that selection in the socio-economic domain is characterized by a sequence of interdependent internal and external selection mechanisms (Hodgson, 2002).

It is generally assumed that selection reduces heterogeneity in a population. For instance, Friedman (1953) suggests that profitability of a firm is related to its fitness and only profitable firms can survive upon selection, which leads to a homogeneous profit maximization behavior. Evolutionary economics rejects the concept of representative firm and embraces heterogeneity of actors as one of its building blocks. However some studies in this strand of research suggest that heterogeneity is diminished by increased rates of selection intensity. For example, Metcalfe (1994) suggests that the variance of behavior is driven to zero by selection; hence it can be assumed that selection reduces heterogeneity, leading to the convergence of firm goals.

The assumption of reduced heterogeneity due to selection may hold true, if the selection environment is stable for a considerably long time. However Richerson et. al. (2005) describe the selection environment as a restless world with irregularly changing selection criteria over time, thus selection in this sense creates new niches and stimulates variation, which in turn increases heterogeneity. Moreover, even if selection leads to homogeneity of firm goals, still a broad range of strategies can be pursued. Levinthal (1997) argues that in a simple environment firm strategies may converge to a single solution, or global optimum. On the other hand, as the complexity of operating environment increases firms may adopt different strategies, leading them to follow distinct trajectories. As noted by Hodgson and Knudsen (2006) selection does not always lead to an optimum solution, yet it may yield a better outcome if it operates in a more diverse environment. Expected improvement in fitness is increased with the amount of variability upon which selection acts. (Safazynska & van den Bergh, 2010) Depending on the unit of selection, diversity of actors, technologies, institutions should always be an important element of an evolutionary framework.

2.1.3.3 Retention

Sustainability of the evolutionary process is provided by retention, which maintains positively selected variations (e.g. patterns of behavior, skills, competencies etc.) through growth of incumbents or entry of new firms. According to Godfrey-Smith (2000) replication, which explains the heritability of variation, requires similarity in relevant aspects. In this sense, retention can be characterized by the relationship between the source and its copy. Som (2012) lists the aspects of this relationship as follows:

- Causation: The source must be causally involved in the generation of its copy
- Similarity: The copy must exhibit some degree of similarity to its source in relevant aspects
- Information transfer: The process that generates the copy must obtain the information about what makes the copy look similar to the source from the source
- Duplication: Retention should give rise to two or more others

Retention, which is characterized by the aspects listed above, is the element of stability in the evolutionary process. Achieved characteristics and qualities are preserved and accumulated by the process of retention. Knowledge stock accrued over time as a result of retention is used to produce new variations. Variation and selection are the dynamic elements of the evolutionary process. Retention, on the other hand, provides coordination and stability.

Unit of replication in the biological domain is the gene. Darwinian view of biology suggests that replicators in the form of genes or DNA manifest themselves in the characteristics of the interactors (i.e. species) that are carrying them. Winter (1971) suggests that decision rules are the counter part of genetic inheritance in social sciences. Nelson and Winter (1982) put this idea at the very core of their theory as reflected in the quote mentioned below:

> *"Our general term for all regular and predictable behavioral patterns is 'routine'. In our evolutionary theory, these routines play the role that genes play in biological evolutionary theory. They are a persistent feature of the organism and determine its possible behavior (though actual behavior is determined also by the environment); they are heritable in the sense that tomorrow's organisms generated from today's (for example, by building a new plant) have many of the same characteristics, and they are selectable in the sense that organisms with certain routines may do better than others, and, if so, their relative importance in the population (industry) is augmented over time".* p. 14

According to Hodgson (2008) habit is the individual disposition of social or economic actors to engage in previously adopted or acquired behavior, triggered by specific stimuli. At the level of firm or organization, habits correspond to routines, which display regularity. In fact Winter (1964) defines a routine as patterns of behavior that is followed and repeatedly, but is subject to change depending on the conditions. Therefore, routines consist of knowledge, competencies, skills and experience.

Genes can be transferred from one generation to another through sexual reproduction. However in the socio-economic domain, there is not a simple mechanism of reproduction and routines cannot be easily transferred. On the contrary, knowledge and skills embedded in routines need to be actively acquired and absorbed by organizations.

2.1.4 Remarks on the Evolutionary Economics Literature

It can be argued that evolutionary economics provides a solid anti-thesis to the neo – classical school of economics, which is built on the assumptions of profit maximizing behavior and states of equilibrium. Entities under consideration in evolutionary economics (i.e. individuals, firms etc.) are presumed to be unable to globally optimize their decision making processes. Therefore, economic agents, which are only 'boundedly' rational, depend on rules and heuristics in their operations. These 'rules of thumb' or routines are prone to vary over time in order to adapt to changing operating conditions. In this sense, economic agents still seek for profit maximization; however they can only assess the outcome of their operations as being satisfactory or unsatisfactory depending on the context and the actor's perception of the environment.

Aggregate economic performance is attributed to the interaction between variation and selection. Deviations from established routines, strategies, processes or problem solving methods constantly introduce novelty to the system, whereas selection mechanisms tend to reduce this variation by eliminating alternatives with less adaptive capacity to changing conditions.

This dynamic view of evolutionary economics is convenient in explaining the heterogeneity of innovative behavior within a sector. Continuous efforts to adapt to ever-changing circumstances and selection, which occurs according to time-varying criteria at different levels results in heterogeneity of firms nested in a sector. However different strands in evolutionary economics have not yet converged to a coherent theory of economic change.

Leading scholars from the evolutionary school such as Geoffrey Hodgson claim that Universal Darwinism is not extending biological phenomena to other domains. Since the most important and incontestable evidences pertaining to Darwinian notion of evolution are found in genetics, it is almost inevitable to deduct generalizations from biological principles. However there is a difference between generalization and analogy. While making analogies, phenomena and processes in one domain are taken as a reference point for the analysis of resembling phenomena or processes in another domain. Mismatching issues are treated as dis-analogies. For example novelty, i.e. mutation, in genetics is almost purely blind; whereas human intentionality plays a crucial role in technological change. Selection mechanism in the biological domain operates on the phenotypic characteristics, which in turn determines the relative frequency of a certain genotype in the gene pool. Generalization of the Darwinian notion of selection to the socio-economic domain leads to ambiguous results. In biological evolution transmission of the replicators, i.e. genes, is dependent on the survival of the interactors, i.e. carriers of the genes. Interactors that are unable to adapt to altering conditions are eliminated. On the contrary even if economic agents (i.e. individuals, firms, etc.) are eliminated from the socio-economic domain, their rules and routines do not disappear.

Interactors can develop new traits; however this does not result in the modification of replicators. On the other hand, entities in the socio-economic domain can purposefully alter their routines and seek for new methods, which in a sense is very similar to the Lamarckian notion of evolution.

Mechanisms of replication also exhibit differences in biological and socio-economic domains. Genes of the survivors are exactly copied and transferred to the next generations. Deficiencies in the replication process lead to mutations. In the socio-economic domain replication depends on duplication and imitation of knowledge and other capabilities at different levels. This process occurs through study, communication and learning. These cognitive processes are assimilated into mental models, which in turn determine the choice of rules and routines that are perceived to be successful. Consequently, retention in the socio-economic domain is substantially voluntary and resembles to the Lamarckian notion of evolution as well.

Empirical analysis of this thesis starts with identifying different groups of innovative firms, which can be analogous to 'species' (defined within a phylogenetic classification) in biology. This classification is based on the discernible characteristics of firms and the temporal dimension of the analysis is in line with the dynamic view of evolutionary economics. Accommodation of such analogies provides a useful framework for the design of models and interpretation of results. However this reasoning is far from an attempt to generalize the principles of Universal Darwinism to explain the heterogeneity of innovative behavior within sectors. This thesis is more oriented towards the neo – Schumpeterian theme advocated by Richard Nelson (2006; 2007), rather than the proponents of the Universal Darwinism such as Geoffrey Hodgson (2006).

2.2 Strategic Management View on Heterogeneity

Strategic management literature mainly focuses on the differential performance of firms within the same line of business. Two main branches, namely the market based theory of strategic management and the resource based theory of firm emerge in this field. In the market based theory of strategic management, early contributions by Michael Porter (1979; 1980; 1985) were much inspired by the structure-conduct-performance (SCP) paradigm. According to this paradigm, performance of a sector depends on the conduct of firms nested in that sector, which in turn is related to the sector's structure. On the other hand, resource based theory of the firm attributes persistent differences in firm performance to firm specific sets of strategic resources or resource combinations[4] (Wernerfelt, 1984; Rumelt, 1984; Barney, 1986).

[4] As shall be explained in subsequent sections, Edith Penrose's "Theory of the Growth of the Firm" is largely accepted as the starting point of the resource based view.

2.2.1 The Market - Based View of Strategic Management

Porter's (1980) analysis starts with a criticism of SCP paradigm on the grounds of neglecting the market behavior of economic actors in empirical studies. Porter mainly argues that the market behavior of firms depends on their competitive strategies (ibid). According to Porter, the differential performance of firms within the same line of business stem from their different strategic behavior. On the other hand, Porter (1985) also argues that a firm can guarantee economic success only by thoroughly analyzing the market structure and implementing a suitable competitive strategy. According to Hoskisson et. al. (1999), Porter's conception of competitive advantage is determined by the nature of the sector in which the firm is operating and the strategic decisions by which it positions itself in that sector.

Porter (1985) states that the competitive advantage of firms resides in their relative market position (i.e. position of the firm in terms of market share, size, financial strength with respect to its competitors), which can be managed by adapting to sector - specific competitive forces and choosing the optimal strategy. Accordingly Porter developed five competitive forces, which focus on the characteristics of clients, suppliers, entry barriers to new competitors and the risk of product substitution (ibid). Firm's relative position in a market, based on these competitive forces, is decisive on its strategy formulation. Competitive forces of markets in this sense are universal and are indifferent to product or service markets. Porter's (1985) competitive forces are illustrated in Figure 2.

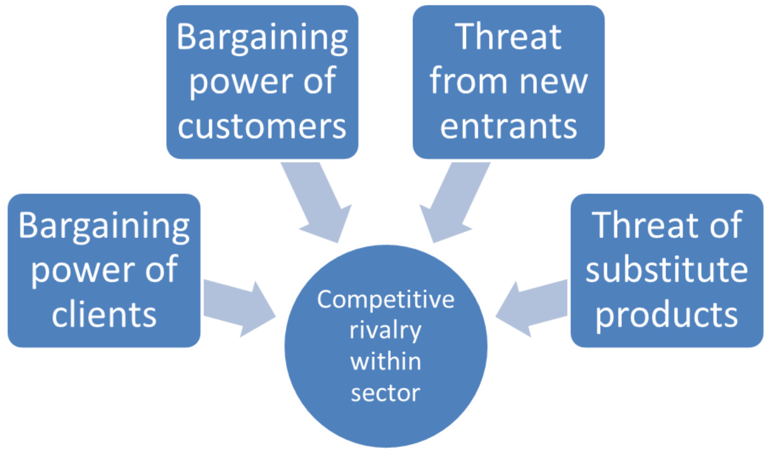


Figure 2 Porter's (1985) model of five competitive forces

In a perfectly competitive product (and resource) market, no producer should be large enough to exert market power to influence prices; products should be identical with the same price; there should be no restrictions on entry or exit; and all agents should have perfect information. According to Ambec and Barla (2002) markets deviate from this state due to knowledge spillovers, learning-by-doing, exercise of market power, asymmetric and incomplete information and agency control problems. Porter's framework describes such market imperfections due to competition and their effects on firm strategies (Hoskisson et. al., 1999). Therefore, the most important strategic goal in this framework is identification of the optimal market position such that the influence of these market forces can be absorbed. Building upon these market forces, Porter proposes three distinct competitive strategies, which can be adapted according to the market force conditions (Porter, 1985). These strategies are:

- Differentiation
- Cost leadership
- Niche market

Porter (1985) strictly mentions that a firm should choose only one of these strategies to obtain maximum benefit. According to Porter, if a firm cannot make a clear decision in favor of one of the strategies mentioned above, it has to face the risk of losing customers, which either demand different products or lower costs. Porter's framework suggests that firms possess similar resources, and even if they do not strategic resources can be easily acquired and utilized. This view is manifested in the quote mentioned below (Porter, 1991):

> *"Resources are not valuable in and of themselves, but because they allow firms to perform activities that create advantages in particular markets"*

Therefore, market conditions, rather than the endowment of strategic resources is the starting point of strategy formulation in Porter's framework. Porter's five force model is easy to apprehend, thus it is frequently used in strategy formulation. However it is also subjected to severe criticism.

Porter's suggestion of choosing only one strategy is scrutinized by Cronshaw et. al. (1994), who analyze 16 brands associated with a product (or product line) that have competitors both at higher and lower ends. Their results indicate that products that have a medium cost and medium quality can provide higher return to investment when compared with products that have low – low and high – high positions in terms of cost and quality. Their results indicate that intermediate positions (in terms of cost and quality) can also be profitable and are successfully exploited by many firms. Moreover Porter's framework implies that firms can switch between strategies depending on market conditions. However initial resource endowments and adapted strategy results in path dependency, hence firms cannot alter their technological trajectories without bearing losses due to investment costs (Dosi, Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change, 1982).

2.2.2 Resource - Based Theory of the Firm

Resource based theory of the firm also focuses on the differential performance of firms within the same line of business, but unlike the market based view the resource based theory attributes competitive advantage to internal assets and resources possessed by firms. Therefore, firms should either possess unique or superior resources or have the ability to exploit these resources more efficiently than their competitors in order to gain competitive advantage and economic success (Mahoney, 1992; Peteraf, 1993).

Edith Penrose's famous book "The Theory of the Growth of the Firm" (1959) criticizes the neo-classical abstraction, which assumes that firms can be modeled by relatively simple production functions. Penrose conceptualizes the firm as a bundle of productive resources, which are utilized under an administrative framework coordinating the individuals and groups within the firm. Following quotation underlines this view:

> *"A firm is more than an administrative unit; it is also a collection of productive resources the disposal of which between different uses and over time is determined by administrative decision. When we regard the function of the private business firm from this point of view, the size of the firm is best gauged by some measure of the productive resources it employs" p. 24*

According to Penrose (1959) learning process, simultaneously taking place alongside with the production operations of the firm, adds to the knowledge stock of the firm, which in turn expands firm's productive opportunity set. Neo-classical view attributes firm growth to adjustment to equilibrium size. On the other hand, Penrose suggests that expansion of firm's productive opportunity set eliminates the notion of equilibrium size. In Penrose's view, productive resources vary significantly amongst firms even in the same sector. Penrose provides a broader definition of productive resources, suggesting that firms display a great variety of these, instead of sharing the same homogenous set of resources.

As has been mentioned in the previous sub-section the structure-conduct-performance (SCP) paradigm claims that industrial structure largely determines the range of activities a firm can undertake. Accordingly, superior performance of a firm is an indication of non-competitive firm behavior. Demsetz (1973) criticizes this postulation, suggesting that superior performance of a firm can also be attributed to firm specific factors, which are difficult, if not impossible, to detach from the firm.

Building upon these early contributions, Wernerfelt (1984) attempts to establish a theory of competitive advantage based on the resources a firm owns or acquires to execute its product market strategy. Accordingly Wernerfelt claims that the product market positions that can be held by a firm is dependent on the bundle of resources it controls. Therefore, the resource profile of firms and their competition for resources have implications on their ability to attain competitive positions in a market.

Rumelt (1984) explains the ability of firms to generate economic rents more efficiently than other organization forms by suggesting that the economic value of resources of a firm vary depending on the conditions, in which it operates and the imitability of these resources depends on the extent to which they are protected by isolating mechanisms.

Following this strand of research, Barney (1986) introduces the concept of strategic factor markets, where firms acquire the resources they need to implement their product market strategies. Accordingly, if strategic factor markets are perfectly competitive then acquisition of resources from these markets can be interpreted as a sign of the attainable performance upon the utilization of those resources. However this assumption is not sufficient to explain the differential performance of firms within the same line of business. Barney (1986) suggests that firms may gain competitive advantage if they can better predict the outcome of resources they acquire from or develop in strategic factor markets. This inference leads to the claim that firms can benefit from the resources they already possess better than resources they can acquire from strategic factor markets.

Dierickx and Cool (1989) extend Barney's argument of critical resources accumulating rather than being acquired from strategic factor markets and argue that sustainability of a firm's asset position depends on how easily these assets can be substituted or imitated. In this sense, imitability of critical resources is related to the time compression diseconomy, asset mass efficiency, interconnectedness of assets, asset erosion, causal ambiguity and substitution of asset stocks. *Time compression diseconomy* is related to the law of diminishing returns, i.e. sustaining a certain rate of R&D expenditure over a particular time interval leads to a higher accumulation of R&D stock than maintaining twice this rate of R&D spending over half the time interval. *Asset mass efficiency* is used to describe success breeds success situations, in which firms that have a substantial R&D stock are in a more favorable position to introduce break-through innovations than firms with low initial stocks. *Interconnectedness of asset stocks* is related to the synergy created by bringing together complementary assets. For example von Hippel (1978) suggests firms lacking an extensive sales and support network may find it more difficult to introduce innovative products to the market. According to Dierickx and Cool (1989), a firm's physical assets in addition to its non – tangible knowledge stock are subject to deterioration. They suggest that even in case of rapid asset decay, firms can sustain their competitive advantage due to counter acting effects of *asset mass efficiency* and *asset interconnectedness*. On the other hand, *time compression diseconomy* effects combined with rapid *asset erosion* makes it difficult to sustain competitive advantage. *Causal ambiguity* refers to the stochastic and discontinuous characteristics of the innovation process. Firms may sink considerable investments in research and development activities, which bear significant technical and financial uncertainties. However, the resource stock position of a firm is influential on its probability to success.

Barney's contribution to this strand of research includes application of his resource based views to organizational culture (1986) and to mergers and acquisitions (1989). In his later studies, Barney provides new definitions of resources, which can be used to generate competitive advantage and characteristics of these resources (1991). Peteraf (1993) proposes a model to link resources and firm performance. According to Peteraf four conditions (industry heterogeneity, ex-post limits to competition, imperfect resource mobility and ex-ante limits to competition) must be satisfied in order to gain sustainable competitive advantage. Peteraf relates intra-industry heterogeneity in firm performance to Ricardian rents; hence links her model to microeconomics. Montgomery and Wernerfelt (1988) define rents that are attributable to unique factors such as good management, favorable location, patent monopoly, or brand name strength as Ricardian rents. According to Peteraf (1993), heterogeneity (in terms of firm profitability) within an industry may be an indicator of *superior productive factors* that are limited in supply. Such factors may be fixed (they cannot be expanded) or quasi-fixed (they cannot be expanded immediately). Peteraf's argumentation starts with the assumption that firms with superior resources have the advantage of lower average costs than other firms. However such low cost firms are bounded by inelastic supply curves, i.e. they cannot increase their output rapidly regardless of price. On the other hand, less efficient firms may enter the market as long as the price exceeds their marginal costs. In the equilibrium state, demand and supply are balanced and less efficient firms break-even whereas firms with lower costs earn above-average profits provided *superior productive factors* remain limited in supply. If such superior resources are not limited, then additional low-cost firms will shift the supply curve and decrease the equilibrium price forcing firms with high costs out of the market. In this case, firms will be homogenized and they will accrue normal rents.

Schmalensee (1985) disaggregates business unit profits, reflecting the effects of industrial affiliation, corporate-parent relationships and market share, and reports the importance of industry effects on firm performance. On the contrary, Rumelt (1991), who adds a temporal dimension to the analysis and distinguishes between stable and fluctuating effects, reports that stable business unit effects are much larger than stable industry effects. Similarly, McGahan and Porter (1997) and McGahan (1999) show that business effects are approximately twice as important as industry effects. Moreover Hansen and Wernerfelt (1989) empirically show that specific traits pertaining to firm's organizational culture are more influential than sector level attributes on firm's economic performance.

Main elements and distinguishing features of the resource based view are outlined in the next subsection. From the burgeoning literature on the resource based theory of the firm, some variants also emerged. For example some researchers (Kogut & Zander, 1992; Nonaka, 1994; Connor & Prahalad, 1996; Grant, 1996; Spender, 1996) distinguished between tangible and intangible resources of firms and led to the development of the knowledge based view of the firm.

On the other hand, the relational based view of the firm (Dyer, 1996; Dyer & Singh, 1998; Simonin, 1997; Simonin, 1999; Dyer & Nobeoka, 2000) suggests that competitive advantage largely stems from strategic alliances between firms. This strand of research focuses on the ability of firms to participate in organizational networks and alliances.

Prahalad and Bettis (1986) and Prahalad and Hamel (1990) argue that a firm should have distinct competencies in order to attain competitive advantage based on their existing resources. Teece et. al. (1997) extend the competence based view by focusing on dynamics and changes in the external environment and firms' capabilities to adapt to these changes. Dynamic capabilities concept introduced by Teece et. al. (1997) is outlined in sub-section 2.2.2.4

2.2.2.1 Distinguishing Features of the Resource - Based Theory

As has been shown in previous discussion, resource based literature is rich and has a variety of branches. However Barney (1991) argues that two main assumptions form the foundation of the resource based theory of the firm:

- Reliance on the existence of systematic and empirically observable differences in resource combination of firms
- Relatively stable heterogeneity of firm specific resources, due to their scarcity and limited mobility and transferability

Building upon these core assumptions, Barney argues that a resource should possess the four attributes given in Figure 3 for it to contribute to firm's sustainable competitive advantage.

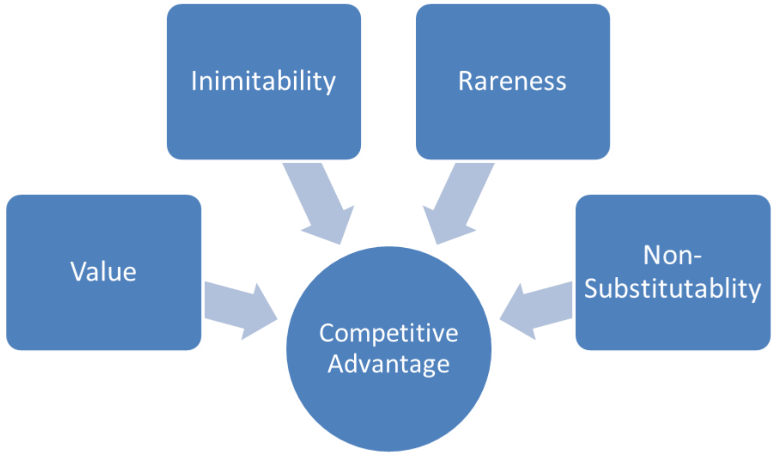


Figure 3 Attributes of resources necessary for firm's competitive advantage (Barney, 1991)

Value of a resource resides in its potential to enable a value creating strategy, which allows the implementing firm to outperform its competitors or reduce its own disadvantages (Barney, 1991; Amit & Shoemaker, 1993).

Value of a resource can also be attributed to its rarity. Competition for a scarce resource in a perfectly competitive strategic factor market sets the price of that resource indicating the discounted value of its above average returns (Dierickx and Cool, 1989).

Inimitability refers to the number of firms which have control over a valuable resource (Barney, 1986). A firm may gain sustainable competitive advantage from a strategic resource, if competitors are not able to duplicate this asset completely (Peteraf, 1993; Barney, 1986). Isolating mechanisms, as defined in Rumelt (1984) prevent competitor firms from imitating a valuable resource. Causal ambiguity is another source of inimitability (Dierickx and Cool, 1989) and it is more pronounced if the resource under scrutiny is socially complex or based on knowledge (Peteraf, 1993).

A resource may be valuable, rare and inimitable, but it must also be non-substitutable by other resources for it to create a sustainable competitive advantage (Dierickx and Cool, 1989; Barney, 1991). If competitors are able to defy a firm's competitive advantage stemming from a strategic resource by replacing that resource by a substitute, then prices tend to decline and diminish profits (Barney, 1986).

These four attributes are commonly accepted in the resource based theory; however the definition of "resource" poses a greater ambiguity. Barney (1991) defines resources as assets, capabilities, organizational processes, firm attributes, information, knowledge sources controlled by a firm. Firms can design and implement strategies to increase their efficiency. This definition underlines the interdependence of resources and strategy since firm's strategy is largely determined by its relative resource position and ability to combine and utilize these resources. On the other hand, this definition also indicates that firm's performance defines whether an asset (tangible or intangible) of a firm can be regarded as a resource or not. Resource based view broadly suggests that if a firm possesses *resources* (that are valuable, rare, inimitable and non-substitutable) then it should have *superior performance*. By reductio ad absurdum, then the statement "firms with *sub-par performance* should be lacking *resources*" should also be logically true. Therefore, firm assets are ambiguously regarded as *resources* depending on performance.

Wernerfelt (1984) provides a much broader definition of a resource as anything, which can be thought of as a strength and weakness of a given firm. Alternatively, Amit and Shoemaker (1993) describe resources as stocks of available factors that are owned or controlled by a firm. Grant (1991) provides another resource definition as inputs into the production processes which resembles to the resource definition in traditional economics.

Focus of analysis may affect the breadth of resource definition, from tangible assets to rather intangible and abstract resources such as firm level competences. Teece et. al. (1997) provide a well-defined taxonomy of firm-level resources as indicated below:

- Input factors: Inputs such as land, unskilled labor and capital, which are undifferentiated and lack a firm specific component, are allocated to this category.
- Resources: Firm specific assets, which are difficult to imitate are regarded as resources. Examples include trade secrets, engineering know-how and specialized manufacturing facilities.
- Organizational routines and core competencies: Organizational routines are distinctive activities which are enabled by the assembly of firm specific assets in integrated clusters. Quality control and assurance practices, miniaturization and system integration are examples to organizational routines. On the other hand, core competences define the fundamental business of the firm. Distinctiveness of a core competence depends on its inimitability.
- Meta competencies: Firm's ability to integrate, build, and re-configure internal and external competencies make up its dynamic capabilities.

In her seminal study, Peteraf (1993) defines the "cornerstones" of competitive advantage, all of which she claims should be fulfilled in order to attain enduring competitive advantage over rivals by protecting, controlling and utilizing firm's internal resources. Model proposed by Peteraf is illustrated in Figure 4.

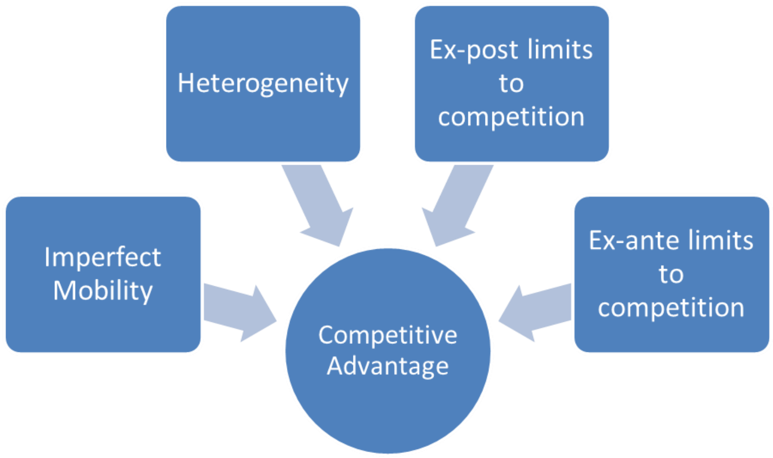


Figure 4 Cornerstones of competitive advantage (Peteraf, 1993)

Heterogeneity: Resource based theory seeks to explain the heterogeneity of firm performance within the same line of business. According to Som (2012) each firm is endowed with a unique set of internal resources, which develop over time through evolutionary processes. Accordingly these firm-specific resource sets constitute a broad heterogeneity, which distinguishes each firm from its competitors in a sector. Nelson (1991) relates intra-industry heterogeneity to distinct characteristics of firm strategy, structure and capabilities.

Peteraf (1993) argues that heterogeneous firms compete in a market and those with marginal resources (resources that do not have the potential to create *more* value) may reach to a breakeven point, whereas firms with superior resources are able to generate rents. Peteraf defines rents as earnings beyond the breakeven point if they do not cause additional competition. Peteraf relates intra-industry heterogeneity to Ricardian rents. Hence firms with superior resources have lower production costs; however they cannot expand their production rapidly, even if the market price is very high. On the other hand, new firms can enter the market as long as their marginal costs are lower than the market price. In this setting, new entrants may reach to a breakeven point, whereas firms with superior resources are able to earn supranormal profits to their resources in the form of rents.

Imperfect Mobility: Another condition of sustained competitive advantage in Peteraf's (1993) model is imperfect mobility of resources. As pointed out by Dierickx and Cool (1989) for internal resources to be instrumental in obtaining competitive advantage, they should possess certain characteristics that they cannot be easily traded or transferred to competitors. Moreover, these resources should lose their value with respect to competitive advantage, when they are utilized outside the firm context. Highly specialized machinery and equipment, highly qualified labor and a firm culture fostering innovation are examples of such internal resources. Apparently, such resources cannot be acquired from factor markets and they should be developed within the firm over time. Co-specialized assets as defined by Teece (1986) can also be regarded as resources with imperfect mobility, since they must be used in conjunction with one another, or they create higher value when used together.

Ex-ante limits to competition: Barney (1986) argues that the economic performance of firms depends not only on the returns to their strategies but also on the cost of implementing those strategies. According to Peteraf (1993) competition for a superior resource position should be limited, before any firm can attain that position. According to Peteraf, if approximately equivalent firms perceive that they can gain an inimitable resource position by a certain location choice, they shall fiercely compete over that position, diminishing their earnings. A superior resource position can be instrumental in gaining above normal returns, only if some firm has the foresight (or good fortune) to acquire it in the absence of competition. Moreover tradable resources can be acquired from the strategic factor markets, but rival firms can obtain non-tradable resources such as client trust over time.

Ex-post limits to competition: Peteraf (1993) argues that heterogeneity (of resource positions) is a prerequisite for sustained competitive advantage. Therefore, subsequent to a firm's gaining a superior position and earning rents, there should be some mechanism limiting the competition for those rents. Ex-post competition can be limited by inimitability and imperfect substitutability (Diericx and Cool, 1989; Barney, 1991). Imperfect substitution may be related to Porter's "five forces" (1980); however Porter focuses on substitutability of products, whereas the resource based theory underlines substitutability of resources. Isolating mechanisms (Rumelt, 1984), such as intellectual property right protection, time lags of introduction, information asymmetries; also limit ex-post competition. Causal ambiguities, which prevent imitators from exactly knowing how or what to imitate, are also influential in constraining ex-post competition (Lippman & Rumelt, 1982)

2.2.2.2 Knowledge - Based View of the Firm

Intellectual resources have become more important than tangible assets for industrialized economies. Knowledge based economies are characterized by production, processing and transfer of knowledge and information at an accelerated rate. Higher importance attached to knowledge as the key driver of economic growth led to the development of knowledge based view of the firm.

Knowledge based view of the firm focuses on firm's specific knowledge bases and its ability to develop its knowledge stock through learning, which are regarded as the main sources of competitive advantage within dynamic market conditions (Spender & Grant, 1996; Grant, 1996; Decarolis & Deeds, 1999). Knowledge based view of the firm builds upon the previous studies on the resource based view (Barney, 1986), capability and competence based analyses (Prahalad & Hamel, 1990; Amit & Shoemaker, 1993) and organizational learning (Levitt & March, 1988; Huber, 1991). Knowledge based view of the firm stems from the analysis of the powerful position of Japanese firms in the 1990's, since their success in rapidly responding to customer needs, creating new markets and dominating emerging technologies is seen as the main driver of their competitive advantage (Nonaka, 1991).

Knowledge based view of the firm can be seen as an extension of the resource based theory of the firm, with specific emphasis on sources related to the knowledge base of the firm (Grant; 1996; Decarolis and Deeds, 1999). On the other hand, Spender (1996) argues that a dynamic theory of the firm based on knowledge should be conceptually different from the resource based view, since knowledge does not represent a directly observable and transferable commodity.

Knowledge based view posits that firms are heterogeneous knowledge bearing entities, which cannot be analyzed only by their contractual positions (Kogut & Zander, 1992). Foss and Foss (1998) suggest that firms should be conceptualized as knowledge developing and utilizing entities rather than contractual entities which exist to align incentive conflicts. Accordingly, firms can be viewed as repositories of distinct technological and organizational knowledge (Foss N. J., 1996). Another important element of the knowledge based view is related to the economies of scale and scope in knowledge. Hence creation of knowledge is assumed to be more costly than its replication and diffusion. Economies of scale, coupled with complementarity of different types of knowledge in specific contexts indicate increasing returns to use of knowledge. Moreover, if knowledge base is not specific to a certain production technique, than it can be transferred to economies of scope.

Classically knowledge is treated as an unambiguous, reducible and easily transferable construct; whereas knowing is equated to processing information. In this conception, an organization’s work is entirely determined by codified knowledge which is held by a limited number of individuals within the firm. Accordingly, rules and routines of an organization are used to address individual information processing requirements due to interdependency of work requirements and uncertainty.

Spender (1996) suggests that two main dimensions of knowledge, namely positivistic-functionalistic and pluralist-interpretative perspectives, constitute the focus of the knowledge based view. Positivistic-functionalistic perspective treats the firm's knowledge base as the objective and rational aggregate of all individual cognitions and capabilities within a firm, which are generated through individual learning processes. On the other hand, pluralistic-interpretative perspective regards knowledge as a context specific and social construct. Since knowledge in this perspective is context dependent, its analysis requires the understanding of social interactions, through which knowledge is generated, shared, used and replicated.

Building upon this conceptual distinction, Nonaka (1994) categorizes firm's knowledge into information and know-how. In this sense, information comprises all the knowledge that can be relayed without any loss of integrity, given the rules required for its deciphering are known. Therefore, information includes facts, data, axiomatic propositions and symbols.

On the other hand, know-how pertains to the accumulated skills and expertise, which makes it possible to perform something efficiently. Accumulation in this description underlines the importance of active learning in the process of building up know-how. Stock and flow dimensions of strategic resources, as introduced by Dierickx and Cool (1989), are also reflected in the knowledge based view of the firm. Persistent variation in firm performance is related to the differences in knowledge stocks and knowledge flows. Hence an important issue in explaining this differential performance is to identify the characteristics of knowledge that hinder its replication and transfer. According to Grant (1996) the type of knowledge, its carriers and content are influential in this analysis.

The first dimension distinguishes between the tacit and codified components of knowledge. Codified knowledge can be characterized by a systemic language, through which knowledge can be replicated and transmitted. Codification isolates knowledge from the individual. On the other hand, tacit knowledge is highly personal and context specific; hence tacit knowledge is hard to formalize and communicate. Therefore, firms need to form mechanisms to transform tacit knowledge into codified knowledge in order to replicate and transfer knowledge, and vice-versa convert explicit knowledge to tacit knowledge (Nonaka, 1994; Nonaka & Konno, 1998).

Tacit knowledge is generated through idiosyncratic experience - based learning processes within a firm. Therefore, tacit knowledge is highly firm specific and cannot be used out of its origin without significant deterioration (Spender, 1996). Tacit knowledge bears the characteristics of valuable strategic resources often mentioned in the resource based theory of the firm. Economies of scale and scope can be attained by codified knowledge, which is expensive to produce but cheaper to replicate (Shapiro & Varian, 1999). According to Grant (1996) replication and transfer costs of tacit knowledge are higher, but still lower than the costs incurred at the initial knowledge generation phase.

Although it is tempting to construct a dichotomy between tacit and codified knowledge (Cook & Brown, 1999) assuming knowledge can possess both tacit and codified dimensions would be more appropriate. Tacit knowledge can be shared among individuals by using a common language. However since tacit knowledge cannot be completely expressed in codes, it remains closely interlinked to the specific context of action. Building upon this distinction between tacit and codified knowledge, other researchers provide more elaborate classifications for knowledge types. For example Winter (1987) lists four dimensions of knowledge as tacitness, complexity, systems dependence and observability. Blackler (1995) provides a finer categorization and presents five types of knowledge as embrained knowledge, embodied, encultured, embedded and encoded knowledge. Sanchez (2001) distinguishes between know-how, know-why and know-what.

Total knowledge stock of a firm may partly reside with the individuals constituting the firm, whereas organizational knowledge is also an important element of firm's knowledge stock. Individuals are the main carriers of both codified and tacit knowledge. However implicit knowledge at the individual level loses much of its value, unless it is transferred and integrated to the knowledge of other members of the organization, or it is amalgamated to some form of organizational knowledge. Therefore, knowledge based view states that only collective knowledge of the firm can be a source of competitive advantage. Firms are not able to gain such competitive advantage, unless they can develop, exploit and evolve a common stock of shared knowledge (von Hippel, Sticky information and the locus of problem solving: Implications for innovation, 1994). Grant (1996) lists important types of such organizational knowledge as follows:

- Common language
- Common forms of symbolic communication
- Commonality of specialized knowledge
- Shared meaning
- Recognition of individual knowledge domains

Firm's organizational knowledge enables knowledge integration among individuals by providing a communication framework. On the other hand, ongoing integration processes also shape firm's communicative framework (Grant, 1996).

Knowledge content is related to the specifity of knowledge. In this sense, possibility of using knowledge related resource outside the firm decreases with increasing specifity of this knowledge set. Specifity depends on the amount of contextual embeddedness; hence it can be argued that the body of tacit knowledge residing within a firm is highly specific. Moreover, synergetic integration of individual and organizational knowledge through long term learning processes is also highly specific to the firm; thus it can also be regarded as a source of competitive advantage.

Knowledge based view of the firm particularly focuses on the process of "knowing" rather than knowledge as a transferable resource (Eisenhardt & Santos, 2002). In this sense, a firm's knowledge base is socially constructed and developed though ongoing social interactions embedded in working practices (Cook & Brown, 1999). Accordingly, learning is an important element of this process. Nooteboom (2009) puts forward three distinct types of learning as listed below:

- Generation of new knowledge by adopting existing ideas, skills, insights from others through communication or imitation
- Learning through collaboration
- Learning from experience

Knowledge based view posits that the firm's competitive advantage stems from the successful integration and building of a firm specific knowledge stock at the organizational level. Therefore, creation of organizational knowledge through integration of knowledge stocks at the individual level is particularly important.

Grant (1996) proposes a number of mechanisms such as rules and directives, in addition to group problem solving and decision making techniques. Therefore, it can be argued that the knowledge based view of the firm makes use of the concept of organizational routines (Grant, 1996; Kogut and Zander, 1992). Constitution of repetitive and recurrent sequences of complex patterns of autonomous interactions between individuals in the absence of rules or directives can be termed as an organizational routine. Hence organizational routines form the basis of collective learning in organizations and also represent a manifestation of organizations memory (Eisenhardt and Santos, 2002).

Some researchers (Simon, 1991; Grant, 1996) argue that individuals are the nucleus of organizational knowledge, since the learning ability of a firm depends on the learning capacity of the individual members of the firm or addition of new members who possess the missing knowledge elements. Therefore, focus in this strand is on the retrieval and utilization of knowledge residing in the personal repertoires of organization's members. On the other hand, a number of researchers claim that integration of individual's knowledge transcends the mere aggregation process, since this integration is a result of complex interactions, which are inseparable from the social context (Nahapiet & Ghoshal, 1998; Kogut & Zander, 1992; Kogut & Zander, 1996; Brown & Duguid, 2001).

In order to utilize knowledge related resources efficiently, firm's knowledge stock and knowledge flows should interact. Kogut and Zander (1992) use the term "combinative capabilities" to explain the intersection of the firm's capabilities to exploit its existing knowledge and to explore the potential of new or recombined knowledge.

2.2.2.3 Relational - Based View of the Firm

Strategic management literature seeks to explain the heterogeneity of firm performance either through market or industry conditions or internal resources, competences and capabilities. On the other hand, embeddedness of firms in collaborative networks is also a major source of competitive advantage (Dyer & Singh, 1998; Gulati, Nohria, & Zaheer, 2000).

Firms cannot gain competitive advantage by acquiring resources from factor markets, since these resources are not characterized by specifity, idiosyncrasy and inimitability. Firms need to internally combine, redefine and modify these resources. However utilizing only internal processes may not be the most effective strategy due to time and cost issues (Hamel, 1991). Therefore, firms may opt to implement strategies aiming to acquire and control missing and valuable resources by collaborating with external partners.

Hamel (1991) views cooperation with external partners as one of the strategic options to acquire missing resources and argues that once these resources are appropriated cooperation becomes obsolete. Therefore, sustainable competitive advantage can be gained only by internally combining these resources obtained through collaboration. In this sense, individual firm remains as the unit of analysis.

On the other hand, Dyer and Singh (1998) and Gulati et. al. (2000) argue that sustainable competitive advantage is directly related to the characteristics of alliances and networks. Therefore, focus on relational based view is on how firms gain competitive advantage and preserve it in alliances and networks.

Dyer and Singh (1998) define the term “relational rents” to describe above normal profits, which are jointly generated in an exchange relationship that cannot be generated by either firm in isolation and can only be created through the joint idiosyncratic contributions of the specific alliance partners. Firms should transform the traditional “arm’s length” market relationships, which are characterized by non-specific asset investments, information exchange restricted to prices, low transaction costs and minimal governance efforts, in order to obtain relational rents. As shown in Figure 5 Dyer and Singh (1998) propose four conditions, which firms should satisfy in order to transform traditional market relations to higher ordered collaboration forms.

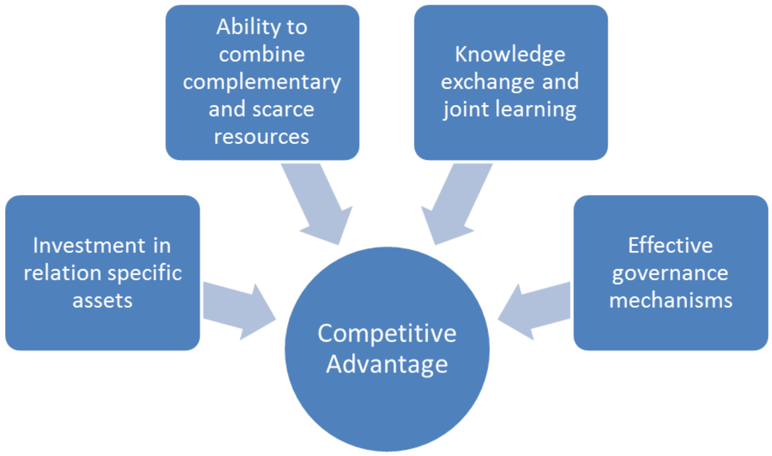


Figure 5 Four conditions to transform traditional market relations to higher ordered collaboration forms (Dyer and Singh, 1998)

As has already been discussed, resource based theory of the firm posits that assets should be rare, valuable, inimitable and non-substitutable. On the other hand, relational based view focuses on the development of resources which are specialized in conjunction with the assets of an alliance. Therefore, Dyer and Singh (1998) define three characteristics of relational assets:

- Site specifity
- Physical asset specifity
- Human asset specifity

Site specifity pertains to the spatial proximity of collaborating partners. Additionally physical asset specifity is related to transaction specific capital investments, such as modified machining tools, machinery equipment or software. Human asset specifity stems from the stock of knowledge accumulated through long term collaboration and joint learning (Dyer and Singh, 1998).

Another condition of obtaining sustainable competitive advantage is given as substantial knowledge exchange between collaborating partners. Accordingly new ideas and novel information are often obtained from partners in a cooperative network. Therefore, collaborating parties should develop regular patterns of inter-firm interactions that permit the transfer, recombination and creation of specialized knowledge (Dyer and Singh, 1998). Firms should develop trust relationships within the network, which are specific to partners and enable absorption of knowledge in order to build such routines.

Firms can also generate relational rents based on the synergy from the combination of complementary resources within the network. Alliance partners are expected to provide distinct resources to the cooperation and combined resource endowments are more valuable, scarce and difficult to imitate than they had been before they were brought together and complemented by each other (Dyer and Singh, 1998). Moreover a firm's experience in cooperative relationships, its absorptive capacity and its ability to obtain critical positions in a socio-economic network increase its potential to create synergy from complementary resources.

Efficiency of network governance mechanisms is also influential in generating relational rents. Dyer and Singh (1998) argue that firms cooperating in a network should coordinate the transactions in order to minimize transaction costs and increase the incentives for partners to engage in value creating initiatives. Governance in a collaborative network can be established through third-party enforcement of agreements, such as legal contracts, or through self-enforcing agreements like informal mechanisms depending on goodwill and trust.

Dyer and Singh (1998) propose a number of isolating mechanisms, similar to those proposed by Rumelt (1984). Apart from isolating mechanisms such as causal ambiguity and time compression diseconomies of scale, Dyer and Singh (1998) put forward four distinct mechanisms to preserve relational rents:

- Inter-organizational asset interconnectedness: Initial relation – specific investments may create conditions that make subsequent specialized investments economically feasible.

- Partner scarcity: Relational rents can be created if a firm can find a partner with complementary strategic resources that is also capable of forming collaborative relationships. Therefore, first-mover advantages may be available to firms that act quick to form alliances thus limit the available collaboration opportunities to other parties.

- Resource indivisibility: Partners in a network may combine their resources or develop joint capabilities, which are idiosyncratic and indivisible. For example a large number of banks that make up the VISA network collectively create and benefit from the brand name and distribution network.

- Institutional environment: Relational rents may occur in an institutional setting that fosters rules and social control mechanisms among the partners.

Potential benefits of inter-firm collaboration and alliances can be hindered due to lack of mutual trust, communication problems, discrepancies in problem solving and decision making methods, differences in learning capabilities and practices or missing management competences (Zaheer, McEvilvy, & Perrone, 1998; Dyer & Singh, 1998). Therefore, analyzing inter-firm relations only from an economic perspective can be misleading, since the collaborative network itself is also a social entity (Gulati, 1998; Das & Teng, 2002). Consequently, reputation, political influence and the ability to appropriate the economic outcome resulting from an alliance, in addition to the overall socio-economic structure of the network affect the potential relational rents (Tsai, 2000; Koka & Prescott, 2001).

Another important aspect of the relational based view is the emphasis on collaborative competences, which can be defined as a firm's ability to maintain and benefit from its collaborative activities (Simonin, 1997; Lorenzoni & Lipparini, 1999). Accordingly, firms should possess both specific technical competences and resources in addition to general immaterial resources, which can catalyze the network relationships to enhance its effectiveness (Lorenzoni & Lipparini, 1999; Kale, Dyer, & Singh, 2002).

Moreover, operational processes (such as management practices, and core business processes like research, product development, production, sales and marketing) of firms engaging in a collaborative relationship should be compatible to a certain degree. Boschma (2005) lists five types proximity, of which cognitive proximity is defined as a function of the similarity of knowledge bases. However effectiveness of the collaborative relationship depends on how each party handles similarities and dissimilarities, rather than the overlapping of their operational process, technological backgrounds or social characteristics.

Social embeddedness of a firm, which is composed of its social positioning and social status within a network, is also influential on its collaborative ability (Gulati, 1998). Inter-firm collaborations are continuous and the behavior and performance of a firm are stored in the collective memory of the network. Therefore, past performance of a firm within a network, in addition to firm's structural positioning constitute an inimitable and non-substitutable resource.

2.2.2.4 Dynamic Capabilities Concept

Teece et.al (1997) define factors of production as undifferentiated inputs available in disaggregated form in factor markets. Undifferentiated in this definition is used to describe inputs such as unskilled labor or financial capital, which lack a firm-specific component. Geographical location, physical capital resources, raw materials, buildings, machinery and plant equipment can also be listed as factors of production (Barney & Clark, 2007).

On the other hand, resources are acquired as the result of a successful asset refinement process of the input factors. Therefore, resources can produce persistent heterogeneity, since firms can withstand competitive pressure by using these resources. According to Teece et.al. (1997) resources are firm specific assets that are difficult to imitate. Trade secrets, specialized manufacturing facilities and engineering expertise are examples of resources. Such resources are difficult to transfer across firms since they contain significant "sticky" knowledge. Thus resources are characterized by firm-specifity, which works as an isolating mechanism (Helfat & Peteraf, 2003).

In order to obtain strategic advantage, firms should possess the ability to deploy, combine and coordinate their input factors and resources more efficiently and effectively than their competitors (Grant, 1991). Amit and Shoemaker (1993) address this issue by defining the term "competence", which is a firm's organizational ability to make use of their resources to achieve their intended strategic goals. Accordingly capabilities are the attributes of a firm, which enable it to exploit its resources in implementing strategies or to improve the productivity of other resources (Barney & Clark, 2007).

Prahalad and Hamel (1990) use the term "core competences" to describe the internal factors of a firm that are decisive on its competitiveness and economic performance. Accordingly core competences of a firm are related to the collective learning process, coordination of diverse production skills and integration of various technology streams. Therefore, core competences should be considered as intangible resources, which are composed of different skills of individuals within or outside the firm and these core competences are refined within the organization over time through the firm's organizational memory. Core competences are characterized by their high value and specifity, rareness, inimitability and non-substitutability as well as the variety of their application domains and their incremental nature.

Teece et.al. (1997) define competences as organizational routines, which are distinctive activities enabled by the assembly of firm specific assets in integrated clusters spanning individuals and groups. Accordingly, organizational routines are viable across multiple production lines and may extend well beyond the firm to embrace alliance partners. Routines can be conceptualized as firm specific repeating patterns of action and hence are supposed to have a significant effect on the innovativeness and economic performance of a firm since the transformation of available resources to desired outcomes is achieved through organizational routines (Nelson & Winter, 1982; Nonaka, 1994; Becker, 2004).

An organization must be able to repeat the actions of resource use, combination and exploitation over time. Such repetitive behavior results in the emergence of sequences, which in turn build up patterns of action. Therefore, it can be argued that is not repeated over time cannot be a routine, hence cannot constitute a competence. This structure is often referred to as “recurring patterns” or “repetitive patterns” (Nelson & Winter, 1982; Teece & Pisano, 1994; Grant, 1996; Dyer & Singh, 1998; Teece, Pisano, & Shuen, 1997). Consequently, routines (thus competences) may disappear if they are not repeatedly used.

Routines and competences are not stable over time. Therefore, firms need to adjust and reconfigure their existing competences or develop new competences in order to be able to respond to sudden market changes and discontinuities. The need to address changing conditions and stimuli establish the starting point of the dynamic capabilities concept.

As has been previously mentioned, firms are continuously forced to adapt to changes in the competitive environment. In addition, firms should continuously seek new ways and possibilities to shape these changes. The dynamic capabilities concept focuses on the question of how firms can sustain competitive advantage by shaping the ecosystem it occupies and responding to external change (Teece, 2007). Therefore, it transcends the traditional resource based view by explaining the competitive advantage by a firm's internal mechanisms or routines to adapt its resource base to external changes. Moreover competitive advantage of firm is also attributed to its ability to recognize the requirements and opportunities for change and to implement the right measures of action

Teece et.al. (1997) argue that the market success of a firm depends on highly firm specific capabilities, which enable the firm to continuously reconfigure and adapt its path dependent and firm specific intangible resources, competences and know-how to dynamic environments. Accordingly dynamic capabilities are defined as the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments. Alternatively they can be defined as the capacity of an organization to purposefully create, extend or modify its resource base.

The term "dynamic capabilities" is built on two conceptual pillars. Accordingly "dynamic" represents the firm's capability to continuously renew and adjust its existing resources and competences corresponding to the dynamic nature of the external environment. Therefore, it can be argued that firm resources and competences are subjected to an evolutionary process comprising variation, selection and retention. On the other hand, the term "capabilities" refers to the ability of integrating, configuring, modifying and exploiting firm's internal and external resources and competences to cope with the challenges and demands coming from the environment.

2.2.3 Remarks on the Strategic Management Literature

Strategic management literature, especially resource based theory of the firm and other competence based theories, brings an important insight on the observed heterogeneity of firms within the same line of business, by positing that a firm's performance is highly dependent on bundles of resources, competencies and capabilities that are highly domain and context specific. The strategic management literature also extends the neo-classical view of passive firm by treating firms as active, operative and developing entities, which do not only react to external stimuli but can also influence and alter boundary conditions. In this setting, firms adapt to new conditions imposed by the competitive environment by continuously developing new competencies and capabilities. However the strategic management literature does not provide all the answers to build an analytical framework either.

Porter's framework, which lays the foundation for the market based view of strategic management, is only suitable for established product markets with stable structures. Therefore, Porter's framework provides little insight on how to formulate strategies in emerging markets, characterized by technological turbulence. Moreover, Porter's framework is inadequate in identifying entry conditions to emerging markets with radically new products.

From a broad perspective, the choice of a strategy pretty much determines the deployment of a certain technology in Porter's framework. According to Tidd and Bessant, (2009) Porter tends to over emphasize the role of business management practices on gaining competitive success, whereas the influence of technological change on industrial structure is underestimated in his framework. Skinner (1984) argues that technology in Porter's framework is associated with a single dimension of firm performance and the effects of technology are related exclusively to higher product quality, higher productivity or product diversification. However, improvements in manufacturing processes may result in lower product costs, as well as higher product quality; hence the role of technology cannot be related to a single performance dimension.

Strategy formulation in Porter's framework requires perfect information about market conditions. Moreover implementing the optimal strategy with given external conditions also requires rational behavior of decision makers. Ability to attain perfect information and making fully rational choices would lead all firms in a sector to adapt very similar strategies; hence market based view of strategic management fails to explain the variety of innovative activity and heterogeneity of firms in a sector.

On the other hand, the resource based theory of firm fails to provide a unified terminology, which Barney and Clark (2007; 22) refer to as "ongoing confusion". Putting forward broad definitions such as "…anything which could be thought of as strength or weakness of a firm." (Wernerfelt, 1984), or "…all assets, capabilities, organizational processes, firm attributes information, knowledge, etc. that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness." (Barney, 1991) creates a terminological misperception. Therefore, it is quite perplexing to construct an analytical framework using this fragmented terminology.

Resource based theory posits that firms gain competitive advantage by acquiring valuable resources and building relevant competencies. On the other hand, resource endowment of a firm is closely related to its competitive position. Direction of causality is not clear; hence neither of these claims can be logically falsified. Moreover the effects of possessing certain resources can only be observed ex-post. Therefore, analyzing a firm's economic performance by focusing on its past resource portfolio is similar to driving a car by just looking at its rear-view mirror. Moreover it is very hard to utilize some key concepts of the resource based theory for empirical analysis. Certain tangible assets of a firm can be accounted for; whereas it is not possible to quantify intangible assets such as rules, routines, competencies, network position, or dynamic capabilities. In fact resource based theory of the firm stresses the importance of these intangible assets and how they cannot be quantified appropriately. This thesis aims to identify different groups of innovative firms and uses latent class analysis for this purpose. Obtained latent classes and class membership probabilities may loosely quantify aforementioned intangible assets; however more direct measures are needed to verify hypotheses built on the resource based view of the firm.

2.3 Economic Aspects of Heterogeneity

It can be put forward that the rate of progress displayed within a particular industry depends on the degree of economic variety contained within it. Nelson (1990) emphasizes the importance of such heterogeneity for economic growth and puts diversity at the core of the evolutionary advance of industries. Nelson argues that the main advantage of capitalism over central planning is offering a wide spectrum of paths in which existing techniques can be improved. Economic growth is often conceptualized as a process, in which all underlying technologies increase the efficiency of production methods. However economic development cannot be solely attributed to quantitative change. Qualitative change alters the composition of sector, whereas structural change results in creation in new sectors. Saviotti and Mani (1995) suggest that technological diversity is a prerequisite for sustainable economic growth.

According to Stirling (1998) diversity (of entities, products, methods etc.) has a bearing on the economic structure, since diversity fosters innovation by providing a hedge against ignorance, mitigating lock – in, and accommodating plural point of views.

Stirling (1998) asserts that diversity can be viewed as a resource pool, which provides some form of flexibility against uncertainty. Utility maximization methods and different portfolio management strategies built on statistical models are used to cope with risks associated to incertitude. Occurrence frequencies of past events under comparable conditions can be used to characterize the outcomes with a single metric. However it is very hard (if not impossible) to ensure comparability of past and future conditions and outcomes. This hurdle may be overcome by focusing on shorter time spans and using a dominating bottom line. On the other hand, the issues of scale, novelty, uniqueness, complexity, change, irreversibility, and incommensurability cannot be overlooked in fields such as industrial strategy, policy analysis and technology assessment. In most real world problems, it is not possible to assign probabilities to outcomes, or define a comprehensive set of consequences. Economic agents may exert an influence on supposedly exogenous events especially in complex and fast – changing environments. Moreover the way particular courses of action are identified by these agents is interlinked with the appraisal of different alternatives. Consequently, agents are forced to make their decisions in an "ignorance zone", which arises as a result of incomplete knowledge, inconsistent information, data variability, conceptual imprecision, differing reference frames, and the intrinsic indeterminacy of many social and natural processes (ibid).

According to Stirling (1998), the concepts of flexibility, robustness, stability, modularity and redundancy can all be viewed as a systematic response to the condition of ignorance; however diversification of strategies emerges as the prominent policy to cope with severe uncertainty and ignorance. This line of reasoning is best reflected in the following quote (Rosenberg, 1996, p. 352):

> *"The pervasiveness of [strict uncertainty and ignorance] suggests that the Government should ordinarily resist the temptation to play the role of a champion of any one technological alternative, such as nuclear power, or any narrowly concentrated focus of research support, such as the War on Cancer. Rather, it would seem to make a great deal of sense to manage a deliberately diversified portfolio that is likely to*

illuminate a range of alternatives in the event of a reordering of social or economic priorities or the unexpected failure of any single major research thrust"

In this sense, strategies depending on the concept of diversification are expected to raise opportunities to take advantage of unforeseen positive developments, while reducing the negative impact of adverse actions. Therefore, economic diversity can be seen as an instrument to increase flexibility by providing an asset that allows a system to absorb changes and still exist (Stirling, 1998).

Processes such as learning by doing, learning by using or learning by scaling[5] combined with other positive externalities can create strong increasing returns to adoption. Dominance of QWERTY keyboard and VHS video format over their superior alternatives are classical and well documented cases of technological lock – in due to positive feedback mechanisms. Therefore, path dependency and lock – in put forward a serious doubt about the assumption that market mechanisms should guarantee long run efficiency for technological choices. Stirling (1998) suggests that some level of diversity should be maintained in any socio – economic system in order to avoid policies, technologies or investments to become locked – in to socially undesirable monocultures, which are susceptible to catastrophic disruption or endogenous failure. For example economic and demographic decline of the city of Detroit can be attributed to its over-dependence on the automotive industry. Detroit's population peaked in 1950, reaching almost two million residents, and steadily declined thereafter. Detroit has the highest unemployment and crime rates among large cities in the United States (Wikipedia, 2014). However economic diversity may also create some negative consequences by increasing transaction costs. If elevated transaction costs are assumed to be analogous to friction, Stirling (1998) suggests that such friction may provide longer term economic benefits to set

[5] Firms can learn to reduce their costs and increase their quality by scaling-up their production.

against the shorter term inefficiencies. In fact, some friction may be necessary for the functioning of markets by eliminating the positive feedback loops and lock – in (ibid). Therefore, higher transaction costs related to maintaining diversity within a system can be viewed as some form of insurance premium to hedge against uncertainty and sudden shocks.

Saviotti (2001) defines "variety" as the number of actors, activities and objects necessary to characterize an economy and puts forward two hypotheses claiming that the growth in variety is a necessity for long term economic growth and growth in variety and productivity are complementary aspects of economic development. Saviotti (2001) argues that demand saturation and productivity growth in incumbent sectors can be overcome by emergence of new sectors. On the other hand, exploration activities required for the creation of new sectors can be acquired from already existing sectors.

Evolutionary economics underlines the selection effects in explaining the relationship between heterogeneity and economic growth. In this sense, economic actors may adopt distinct approaches in order to gain competitive advantage. Moreover it is not possible to determine a priori the best, or the optimal solution, since economic actors have bounded rationality and their decision making processes suffer from considerable uncertainty. Therefore, it can be argued that the potential contribution of an approach selected by a firm to technological advance increases as the number of conceivable approaches that can be adopted by that firm increases (Nelson, 1982). Holbrook et al. (2000) argue that the more competing variants there are of a product, the better the expected quality of the winning variant. Malerba (1992) analyzes the different approaches in miniaturization of semi-conductor chips and concludes that availability of competing technologies, like the integrated circuit technology and techniques to eliminate the need to develop single components, results in better product quality. However, Hodgson and Knudsen (2006) contradict this view and suggest that selection does not essentially lead to optimality or improvement in the former configuration.

As outlined above, selection from a broader spectrum of approaches may foster technological advance and economic growth. Similarly, number of firms within an industry, hence market structure may also affect the selection mechanisms. According to Cohen and Klepper (1992) the more firms there are within an industry with differing capabilities and perceptions, the more likely the industry collectively will entertain a greater share of the possible approaches to a technical problem. The number of firms in an industry has a bearing on the intensity of competition, thus it may also influence the effects of selection mechanisms on economic growth. Cohen and Malerba (2001) argue that a market should move towards a “winning” technological solution or product with increasing intensity of competition.

Intuitively it can be argued that selection should contribute positively to aggregate economic growth, since it eliminates less productive firms. However increased intensity of selection may eliminate smaller firms with high growth potential, while less productive mature firms may remain in the market. For example Nishimura et al. (2005) report that, mature unproductive Japanese firms remained in the market, while younger efficient firms were forced out over a decade of recessive Japanese economy. In another study Bartelsman et al. (2005) compare firm turnover rate (entry plus exit rates) to aggregate productivity growth in 10 OECD countries and argue that the regulatory framework in Europe is less efficient than the one in the U.S.A in promoting the growth of new firms. In their analysis of market selection in France during 90s Bellone et al. (2008) report that firms displaying low profitability and productivity exit markets, and this selection process is more severe for younger firms. Another important aspect of market selection is the post entry performance of new firms. Audretsch and Mahmood (1994) report that firm growth is negatively influenced by firm size, but the likelihood of survival is positively influenced by firm size, market growth and capital intensity.

The breadth effect refers to the extent to which firms within an industry follow distinct, non-competing and independent approaches to innovation (Cohen and Malerba, 2001). Cohen and Klepper (1992) argue that if there are diminishing returns to R&D for a given technological objective, then the negative effects of diminishing returns can be offset by a variety of firms working towards different objectives. Characteristics of competition within a market and consumer preferences may influence the breadth of innovative activities.

Knowledge generated through performing different innovative activities may have complementary elements, which may be combined in order to increase the productivity of a firm's R&D investment. Information generated in the course of an R&D project may also be used in another R&D project as well. Moreover these different R&D efforts may be undertaken across different firms or within the same firm. Complementarity effects may also take a dynamic form when mutually self-reinforcing feedbacks across innovative activities yield increasing returns over time.

There are a number of simulation studies focusing on the diversity of innovative behavior. Iwai (1984) initially considers a static context without any technological change, in which the market tends to select the best available technology. In the second step, imitation, which enables the survival of all firms, is introduced to the model. Technological diversity emerges when innovation is introduced to the model (Iwai, 1984). According to Silverberg et. al. (1988) the emergence of new technologies or innovations results in diverse firm characteristics, which in turn affect the diffusion process of these innovations. Simulation results obtained by Chiaromonte and Dosi (1993) show that diversity has a positive effect on the rate of innovation. Ballot and Taymaz (1999) take into account diversity of decision rules pertaining to capital investment, training and R&D. Their results indicate that diversity of these decision rules is sustained over time and learning does not lead to convergence of rules adopted by firms.

Aforementioned studies outline how diversity of innovative activities can foster technological advance and economic growth. However, diversity cannot be assumed to be a free good, regardless of how it is achieved. Cohendet et. al. (1992) suggest that increasing the heterogeneity of economic activity may be expected to incur elevated production costs (due to relinquished economies of scale) and transaction costs (due to greater information exchange requirements). On the contrary, standardization may provide significant cost benefits, in addition to learning and network externalities and gains in flexibility (Tassey, 2000). In the context of preserving bio-diversity, Weitzman (1992) states that it is not possible to preserve all species, since sustaining diversity may incur significant costs.

These claims are more or less correlated with the so called Jacobian externalities, which depend on the idea that innovation and growth in a region is fostered by the diversity of industrial structure. In this sense a diverse knowledge base stimulates creativity, promotes market entry and competition of new ideas. On the contrary Marshall – Arrow – Romer (MAR) externalities suggest that an increased concentration of a particular industry within a specific geographic region facilitates knowledge spillovers across firms. In MAR models of externalities, innovators cannot capture the entire return of their R&D efforts because some of their innovations are either imitated or improved by other firms without compensation (Greunz, 2003). Imperfect appropriability problem leads them to slow down R&D investment and justifies monopoly rather than local competition. From a different perspective, Porter (1990) argues that competition increases the pressure to innovate, despite returns to innovation may be reduced due to competition. In this sense, economic growth due to regional specialization is common in both MAR models and Porter's (1990) conception. On the contrary, Jacobs (1969) argues that industrial diversity within a region enables the exchange of complementary knowledge, leading to cross fertilization of ideas, which in turn fosters innovation and economic growth.

Paci and Usai (1999) use patent data for Italy and conclude that externalities related to both specialization and diversification positively affect the rate of innovative activity at the regional level, while mentioning that diversity effects are more pronounced in high-technology sectors and metropolitan areas. Shefer and Frenkel (1998) report similar findings for Israel, but only for high-technology sectors. Feldman and Audretsch (1999) state that diversity, rather than specialization fosters regional innovative activity in the United States. Kelly and Hageman (1999) analyze patent data for two-digit SIC industries in the United States and conclude that sectors locate their research activities close to where other sectors also have research facilities, rather than positioning their research proximately to their manufacturing plants. van der Panne and van Beers (2006) compare specialized and diversified regions in terms of innovative firms they accommodate. Their results indicate that specialized regions embody more innovators than diversified regions and incumbent firms' innovativeness is positively correlated with regional specialization. When rapidly changing technologies are considered, innovators in diversified regions display better performance than their counterparts in specialized regions.

2.4 Synthesis

As outlined in previous sections, evolutionary economics and strategic management literature constitute the main pillars of the theoretical framework of this thesis.

Strategic management literature suggests that a firm's resource position, its knowledge stock, capability to generate new knowledge and learning abilities, in addition to its competence in forming and maintaining collaborative ties with networks is decisive on its *strategy*. *Strategy* of a firm involves defining goals, setting up a course of action and mobilizing resources to execute these actions. In this sense, *strategy* of a firm can be seen as a pattern of activity. This activity pattern is shaped by firm's dynamic capabilities. On the other hand, firm's course of actions is also affected by the opportunities and degree of competition in addition to knowledge base and institutional structure of the sector, in which it operates. Therefore, a firm's strategy is also path dependent and it can be characterized by the dominant technological regime in the sector.

Evolutionary economics also focuses on the aggregate effects of change, which is mainly governed by the two main forces *selection* and *variation*, on the underlying population dynamics. In this sense, firms have different characteristics and their merits are assessed by the selection mechanisms. Therefore, selection mechanisms affect the population mean values of the characteristics on which variation is based. On the other hand, these mean values may also be altered by innovation, imitation, learning and blind and random variations (Andersen, 2004). It can be argued that variety generation increases heterogeneity in the population; whereas selective forces tend to reduce it. Theoretical framework built upon this literature review is outlined in Figure 6.

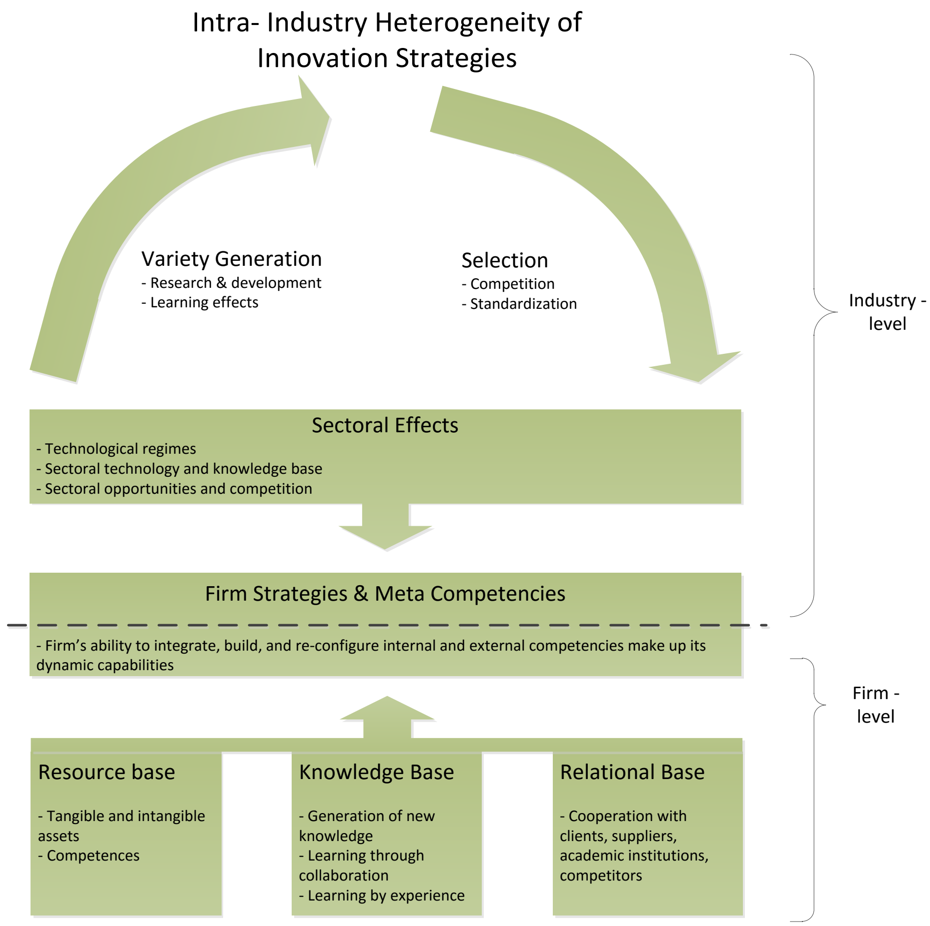


Figure 6 Theoretical framework

Building upon this theoretical framework, research questions laid out in Chapter 1 are translated into the following research objectives:

Objective 1 – Classification of innovative firms: Innovative behavior of firms within a sector may vary depending on firm and sector - level parameters; hence some regularities and patterns related to these parameters also exist. Therefore, first research objective of this thesis is to classify firms based on their innovative aspects. Such classification is also essential to quantify the amount of intra-industry heterogeneity related to innovative behavior of firms.

Objective 2 – Exploration of innovation patterns: Patterns and regularities observed in innovative activities of firms may reflect the effect of technological regimes on firm strategies. For this purpose patterns of innovative activities should be sought and identified.

Objective 3 – Linkage between firm resources and its innovation pattern: Strategic management literature often depends on abstractions from case studies to explain the differential performance of firms within the same line of business. The Third objective of this thesis is to put forward an empirical model to explain the relationship between a firm's resource base and its innovative behavior.

Objective 4 – Quantification of intra – industry heterogeneity of innovation patterns: Evolutionary economics reject the notion of representative firm and puts the heterogeneity of economic actors at its very core; however empirical studies conducted to support this presumption are rather scarce. Therefore, using suitable metrics to quantify intra-industry heterogeneity of innovative behavior is the fourth research objective of this thesis.

Objective 5 – Exploring the determinants of intra – industry heterogeneity: As outlined in Figure 6, variety generation is expected to increase heterogeneity within a sector; whereas selection mechanisms tend to reduce it. Selection and variation work simultaneously; hence the fifth objective of this thesis is to investigate the sector – level parameters that affect intra – industry heterogeneity of innovative behavior by employing a tool that considers the interaction of these governing mechanisms.

Objective 6 – Investigating the effect of intra – industry heterogeneity on productivity: As has been outlined in section 2.3, intra-industry heterogeneity of innovative behavior has economic impacts as well. The final objective of this thesis is to investigate the effects of intra-industry heterogeneity on the innovation process and productivity of firms.

CHAPTER 3

EMPIRICAL FRAMEWORK

This section aims to provide a background for the empirical framework used in this thesis. Primary objective of this thesis is to identify groups of firms with distinct innovative aspects. Therefore, basics of statistical classification techniques are outlined in sub-section 3.1. Following the identification of innovative groups of firms; this thesis aims to examine their dispersion in each sector; hence industrial classifications based on economic activity and innovation indicators are examined in this sub-section as well. Moreover a literature review of firm level classification studies is also provided.

Identifying groups of innovative firms and exploring patterns of innovation calls for utilization of multivariate statistical tools. In addition, predictive modelling techniques should be used to investigate the relationship between firm's resources and innovation pattern. Section 3.2 starts with a brief assessment of statistical tools that can be used for classification, pattern identification and predictive modelling. Selection of statistical tools is justified and methods used in the empirical analysis are introduced in this sub-section.

Another objective of this thesis is to quantify the intra-industry heterogeneity related to differing innovative behavior of firms, which are nested in these industries. Therefore, section 3.3 focuses on the concept of measuring heterogeneity. Various metrics of heterogeneity and their relation to different dimensions of the concept are also elaborated in this sub-section.

The final objective of this thesis is to investigate the effects of intra-industry heterogeneity on the innovation process; hence sub-section 3.4 focuses on the innovation – productivity relationship. Input and output measures of the innovation process, in addition to different productivity measures are summarized followed by an outline of the Crépon – Duguet - Mairesse model (Crépon, Duguet, & Mairesse, 1998).

As shall be outlined in subsequent chapters, various numerical analysis methods based on data from three waves of Innovation Surveys were applied to achieve aforementioned research objectives. Structure and characteristics of data used in this thesis are summarized in section 3.5; whereas section 3.6 aims to provide an ensemble of theory and application domains.

3.1 Classificatory Analysis

3.1.1 Basics of Classification

Classification can be defined as the ordering of entities into groups or classes on the basis of their similarities. General aim of classification is to minimize within-group variance. This means that when a set of entities are arranged into groups, each group should be as different as possible from other groups. Distinction of groups is achieved by maximizing within-group homogeneity and between group heterogeneity. In order to measure similarity, key characteristics on which the classification is to be established should be determined. Individual cases are arranged systematically according to their similarities in classification studies. Therefore, classificatory activities can be regarded as moving from basic observation and description towards systemic and scientific inquiry. In this sense, exhaustive information about single attributes is condensed into a smaller number of significant types. Therefore, classification process focuses on a few dimensions, according to which similarities between entities can be identified (Peneder, 2003). A classification based on trivial characteristics or variables is likely to yield insignificant results. A classification based on “the number of legs” would allocate a dining table, an elephant and a dancing couple to the same group (Bailey, 1994).

Classification process is simply assigning entities into groups. Accordingly, classes formed as a result of the classification problem should be exhaustive and mutually exclusive. Each entity to be classified should be assigned to a group (groups should be exhaustive), but an entity can be the member of a single group (groups should be mutually exclusive). According to Bailey (1994) classifications can refer to typologies and taxonomies. The term typology is related to a conceptual classification, whereas the term taxonomy refers to a classification of entities based upon quantitative analysis (Peneder, 2003). A comparison of typological and taxonomical approaches to classification is given in Table 1.

Table 1 Comparison of typological and taxonomical approaches (Adams, 2003)

Approach	Technique	Role of theory	Application	Output
Typology	Deductive	A priori theory is available to construct different groups	Hypothesis testing based on existing theory	Theoretically-based classification scheme. These may offer a heuristic framework in the form of certain assumptions and constraints to guide further inductive enquiry
Taxonomy	Inductive	A priori theory is absent	Exploratory: Configurations from empirical observations are used as a basis for comparison and classification	Empirically based classification of actual objects. Classifications are empirically-based multivariate classifications may be monothetic or polythetic

If all the cases included in a certain category are identical with respect to every relevant dimension, then the obtained classes are termed as monothetic. On the other hand, entities grouped in polythetic classes are not identical with respect to all relevant variables, but they show significant similarity. Classifications can also have a temporal dimension. A classification is termed as synchronic, if it refers to the characteristics of an observation at a given point time, whereas diachronic classifications are based upon patterns of change.

3.1.2 Classification of Industries and Firms

3.1.2.1 Industrial Classifications Based on Economic Activity

Classification systems are commonly used to analyze the specific activities in certain segments of the economy. Industrial affiliation and size distribution of firms are the most commonly used arguments to identify these segments in an economy. From a hypothetical point of view, if it were possible to isolate very similar firms using a classification system, then it would be possible to explain the variety in their economic performance by the differences in their management practices. For example, industrial classification systems can be used to compare the profit – earnings ratio of firms within the same line of business (Kahle & Walkling, 1996). Moreover Schmalensee (1985) disaggregates business unit profits, reflecting the effects of industrial affiliation, corporate-parent relationships and market share, and reports the importance of industry effects on firm performance.

Classification systems can be used to group economic activities and products based on their similarity. The International Standard Industrial Classification of All Economic Activities (ISIC) and Statistical Classification of the Economic Activities in the European Community (NACE) are used to categorize economic activities, whereas Central Product Classification (CPC) and Central Products by Activity (CPA) are used to group products. European Union and World Customs Organization use the Combined Nomenclature (CN) and the Harmonized Commodity Description and Coding System (HS) respectively to classify goods. United Nations maintains the Standard International Trade Classification (SITC) system mainly to compile international trade statistics. Relationship between these classification schemes is depicted in Figure 7.

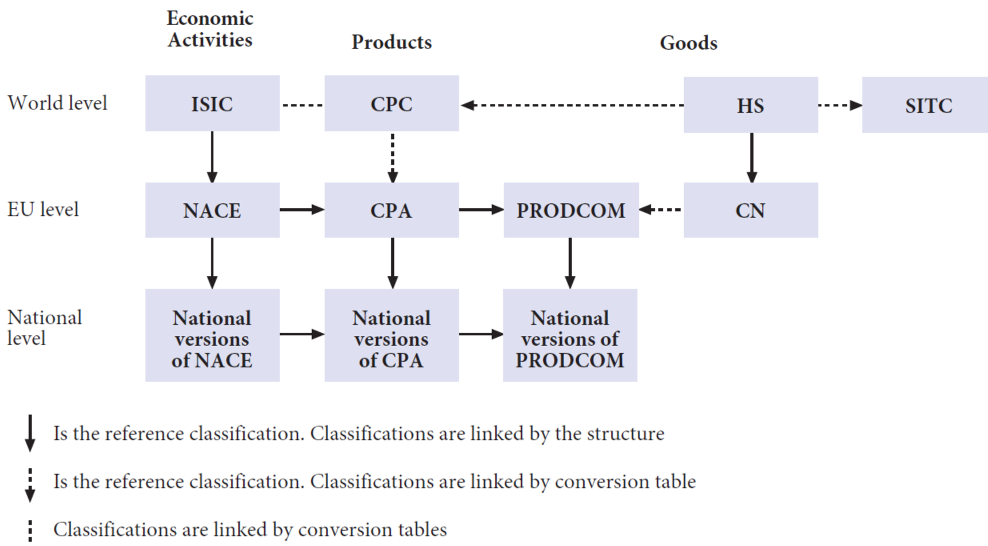


Figure 7 International classification systems (EUROSTAT, 2008)

Discussion of product related classificatory schemes is beyond the scope of this thesis; however ISIC and NACE classification systems are outlined in Appendix – A.

3.1.2.2 Industrial Classifications Based on Innovative Activity

According to Godin (2004) ratio of R&D expenditures to production at the industry level is a simple indicator of innovation, according to which sectors can be classified. Godin (2003) states that an indicator is a statistics of direct normative interest, which facilitates concise, comprehensive and balanced judgments about the condition of major aspects of a society. Therefore, the ratio of R&D expenditures to gross output (or value-added, or sales) is popular among policy makers despite its conceptual and methodological problems. Hoffmeyer (1958; cited in Godin, 2004) groups 11 industries into four groups by their "research" intensity, which is calculated by dividing the R&D expenditure to sales at the industrial level.

Simple indicators have been used to analyze the innovativeness of firms and industries since 1930's. According to Godin (2004) Department of Engineering and Industrial Research of National Research Council in the United Kingdom classified firms into four groups in 1933, based on their R&D expenditure to sales ratio. Similar studies were conducted in the USA by National Association of Manufacturers, US Bureau of Labor Statistics and National Science Foundation throughout 1940's and 50's.

In a background study prepared for OECD's first ministerial meeting for science, Christopher Freeman, Raymond Poignant and Ingvar Svennilson (OECD, 1963) classified industries into three groups according to their research intensities. In this sense, aircraft, vehicles, electronics, other electrical, machinery, instruments, and chemicals industries constituted the research intensive industries. The importance of these industries was emphasized due to their high-growth rate, their increasing share in the world trade and their higher balance of technological payments (OECD, 1963).

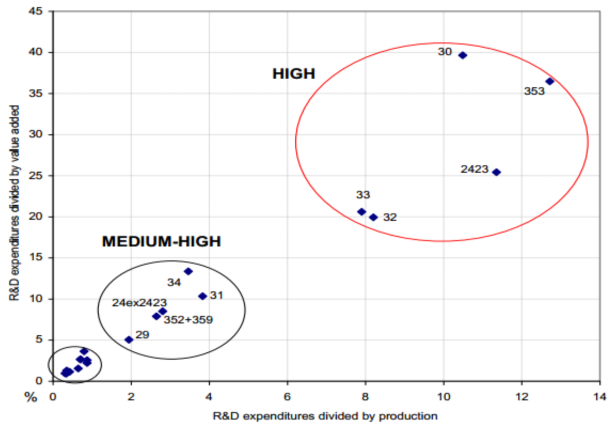
Using the same indicator, OECD identified four industry groups as science based, mixed, average and non-science based industries. OECD focused on product groups rather than industries and used 50 products to classify industrial R&D. Obtained data was used to show the role of science based industries on the international competitive position of nations in terms of export performance. This study underlined the superior performance of the USA over European countries (Godin, 2003). Classification of industries according to their research intensity is shown in Table 2

Table 2 Classification of industries based on technological intensity (Godin, 2003)

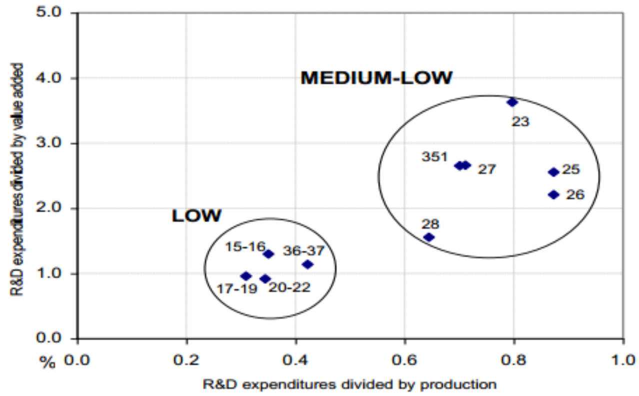
Science based	Mixed	Average	Non-science based
Aircraft Electronics Drugs Chemicals	Machinery Fabricated metal products Petroleum	Non-ferrous metals Ferrous metals Other transport equipment	Textiles Paper Food and beverages Misc. manufacturing

While the technological gap between the USA and Europe was debated in 60’s, the USA set up an interdepartmental committee in 1967 to examine the American investments and operations in Europe. This committee reported that 80% of all American direct investments in manufacturing in Europe were in research – intensive industries. The interdepartmental committee recommended the Department of Commerce to carry out in-depth analytical studies on technological disparities and international flow of technology on a continuous basis. As a result, Department of Commerce developed the technology intensity indicator, which consists of R&D expenditures, scientific and technical manpower and skill level of employees to classify products. According to early reports issued by the Department of Commerce, industries manufacturing technology intensive products represented 14% of the US gross domestic product, employed %60 of all scientific and engineering manpower and carried out 80% of all non-defense R&D activities. However these reports also contained warnings about the eroding competitive position of US in the international markets (Godin, 2003; Godin, 2004).

The term high-technology slowly replaced technological intensity beginning from the mid 80’s, since the dominant paradigm in this era suggested that high technology industries grow more rapidly than other sectors in international trade. OECD (1986; cited in Godin, 2004) formed three groups of industries and products, based on their technological level. This initial classification suffered from low breadth of covered industries and over-simplification of product-industry relationships. Therefore, OECD in collaboration with EUROSTAT relayed a new classification in 1994, grouping industries and products into 4 groups. OECD’s latest technology intensity classification in accordance with ISIC rev.3 is presented in Figure 8. OECD used both R&D expenditure over gross output and R&D expenditure over value added ratios for this classification (OECD, 2011).



Classification of industries based on 1997 aggregate data



Zoom on medium-low and low technology industries

Figure 8 Technology intensity of manufacturing sectors (Source: OECD, 2011)

OECD's classification covers only manufacturing industries. On the other hand, EUROSTAT classifies both manufacturing and service sectors. Classification of manufacturing industries is similar to OECD's grouping, whereas service sectors are broadly divided into two groups, namely knowledge based services and less-knowledge based services.

3.1.2.3 Technological Regimes and Pavitt's Taxonomy

Dosi (1982) defines technology as a set of pieces of knowledge, which has practical and theoretical components. Accordingly, artifacts contain the past achievements in the development of a technology in a defined problem solving activity. Moreover, particular expertise in a given area in addition to the knowledge and achievements of the state of the art make up the disembodied part of the technology. In this sense, technology includes the perception of a limited set of possible technological alternatives and of notional future developments. Dosi's definition technology can be regarded as Kuhn's definition of science.

Keeping parallelism with the Kuhnian view of science, Dosi (1982) puts forward the concept of a technological paradigm as a model and platform of solution of selected technological problems, based on selected principles derived from natural sciences and on selected material technologies. Building upon this definition, Dosi (1982) proposes the concept of technological trajectory as the pattern of normal problem solving activity based on a technological paradigm. Therefore, a technological paradigm embodies strong prescriptions on the direction of technological change.

Technological regimes concept, put forward by Nelson and Winter (1982) and Winter (1984) shares theoretical foundations with Dosi's technological paradigm. According to Malerba and Orsenigo (1993), technological regimes consist of four fundamental factors; technological opportunities, appropriability of innovations, cumulativeness of technological advances and properties of the knowledge base. Likelihood of introducing a successful innovation for a given amount of investment is related to the notion of technological opportunities. Appropriability of innovations is related to the possibility of protecting innovations from imitators and reaping the benefits of the successful innovation. Cumulativeness of technological advances states that past knowledge base and experience determine the future direction of innovative activities.

Firms within the same technological regime are likely to have resemblances in organizational traits and behavioral patterns. In addition technological regimes concept emphasizes the importance of sectoral patterns on technological change. On the other hand, technological paradigms and technological regimes concepts originate from the same evolutionary tradition, of which hallmark is rejecting the idea of representative firm and assuming heterogeneity and bounded rationality of economic agents. Accordingly sectors are characterized by technological regimes, which have a converging effect on firm behavior within a sector; whereas each firm is inherently different from each other.

Following this strand of research, Malerba and Orsenigo (1995) suggest a taxonomy of innovative patterns with respect to the learning forms of firms over time. Malerba and Orsenigo (1996) argue that their sectoral classification based on Schumpeter's Mark I and Mark II models should be able to identify most technological classes. Accordingly Schumpeter's Mark II regime is characterized by a concentrated market with an oligopolistic structure, in which large incumbents firms are the main sources of innovation and productivity growth. On the other hand, Schumpeter's Mark I model is dominated by new innovators, which challenge the position of incumbents with radical innovations. Breschi et. al. (2000) argue that the specific pattern of innovative activity in an industry is related to the characteristics of the dominant technological regime in that industry.

Pavitt's (1984) influential study provides a holistic approach on how technological regimes emerge in different industries. Pavitt uses a database consisting of 2.000 significant innovations introduced between 1945 and 1979. This data set covers 3 and 4 digit product groups, which constitutes about the half of the United Kingdom's manufacturing output. Due to the sparse character of data, Pavitt aggregates the related information to eleven 2-digit and twentysix 3 and 4 digit product levels. Pavitt compares and classifies industries according to the sources of technology used in the innovation process, nature of the developed technology, sectors in which these innovations were adopted and firm level characteristics such as size and principal activity. Using these variables Pavitt constructs his taxonomy and identifies four distinct groups in manufacturing industries: 1) supplier dominated, 2) scale intensive, 3) specialized suppliers, 4) science based sectors.

Pavitt (1984) reports particularly high internal R&D expenditures and substantial knowledge flow from universities and other research institutions in science based industries. Scale intensive industries are characterized by high level of R&D investments, directed towards process innovations and cost cutting activities. Specialized supplier industries are populated with medium and small sized firms, which primarily focus on product innovations. On the other hand, supplier dominated industries have lower capacities for conducting in-house R&D.

Evangelista (2000) presents a classification of service industries using firm level data from the Italian innovation survey covering the years 1993 and 1995. Evangelista aggregates 11 variables at the sectoral level and uses factor analysis to group 22 service sectors. Evangelista identifies four industry groups; 1) technology users, 2) science and technology based services, 3) interactive and IT based services, 4) technical consultancy. Marsili and Verspagen (2002) employ discriminant analysis to identify technological regimes in Dutch manufacturing sectors and argue that there exist more disaggregate industrial classifications than Schumpeters's Mark I and Mark II models. Pol et. al. (2002) build their analysis on the distinction between enabling and recipient sectors and form a taxonomy of manufacturing industries, which consists of 4 groups. Castellacci (2008) analyses both manufacturing and service sectors based on the level of vertical integration and technological content of sectors and divides industries into 8 groups. Peneder (2010) aims to integrate firm level variety with industrial classification. Peneder groups firms based on their innovative behavior (creative vs adaptive behavior) and four fundamental factors of technological regimes suggested by Malerba and Orsenigo (1993). After classifying firms, Peneder uses cluster analysis techniques to group industries based on the concentration of each firm group within an industry.

Audretsch (1997) states that the most important factor shaping the evolution of firms belonging to a specific industry is the knowledge condition shaping the technological regime underlying that industry. Studying the data gathered from 24.000 business units in Italy, Archibugi et al. (1991) propose a new taxonomy of sectors, based on industrial concentration, propensity to develop product vs. process innovations, and the sources of technological change, arguing that sectoral differences are most influential in the explanation of technological change. Klevorick et al. (1995) build upon the concept of technological opportunity to explain inter - industry differences and conclude that inter – industry differences in the strength and sources of technological opportunities contribute importantly to explanations of cross – industry variation in R&D intensity and technological advance. Studying the characteristics of 105 Greek manufacturing firms, Soutaris (2002) argues that important determinants of innovation differ in industries according to four classes of Pavitt's taxonomy.

Although empirical methodology and measurement of concepts may vary in these studies a common finding emerges: Industries differ with respect to firms' innovation behavior and these differences matter for industry structure and innovativeness. In addition, despite the emphasis on bounded rationality and heterogeneity of firms in their operations, this literature depicts a firm, of which innovative behavior is largely industry specific. In his later work Archibugi (2001) argues that technology based taxonomy of firms loses much of its relevance, if it is applied to firms after they have been aggregated into industries according to an output based classification. Therefore, firm level classification studies are performed to capture the variety of innovative behavior.

3.1.2.4 Firm Level Classifications

Cesaratto and Mangano (1993) focus on Italian manufacturing firms and use multivariate statistical techniques to form 6 groups, which represent the underlying technological regimes. Their findings indicate that multiple technological trajectories may exist within a sector. Arvanitis and Hollenstein (1997) use firm level data on Swiss manufacturing and identify five different innovation modes, which have low correspondence to industrial affiliation, i.e. no sector is dominated by a single innovation mode. With a similar approach Hollenstein (2003) performs a cluster analysis on firm level data to identify innovation modes in Swiss service sector. Hollenstein identifies five distinct innovation modes and concludes that a classificatory procedure based on firm level data is more appropriate than an approach which ranks industries according to their innovativeness, because information related to the variety of innovative behavior is lost when firm level data is aggregated into sectors. de Jong and Marsili (2006) focus on small and micro firms in the Netherlands and they report the existence of four categories of small innovating firms dispersed in various sectors. Jensen et. al. (2007) use the 2001 Danish DISKO survey to divide firms into different groups of knowledge such as the science, technology and innovation mode and the doing, using, interacting mode. Their findings indicate that firms active in both modes have superior performance in product innovation. Leiponen and Drejer (2007) compare the innovation patterns of Finnish and Danish firms and identify similar groups, of which categories exceed specific industries. Srholec and Verspagen (2008) use firm level data from 13 different countries to assess the heterogeneity of innovation process. They identify four innovation patterns and claim that sectors and countries matter to a certain extent in explaining the heterogeneity of innovation process, but far most of the variance is given by the heterogeneity of firms within either sectors or countries. Battisti and Stoneman (2010) use the UK CIS4 data to identify different modes of innovation. They also use factor analysis and clustering techniques to form distinct groups. They identify two modes of innovation as wide innovation activities and traditional activities and report that these two modes complement each other.

Yurtseven and Tandoğan (2012) use the 2006 Innovation Survey data for Turkey and identify 4 different modes of innovation by exploring the interdependencies and correlations between variables through a 2 stage factor analysis. Networked R&D mode incorporates R&D and design and marketing, in addition to other dimensions describing the sources of information. Moreover this pattern also includes organizational innovation and cooperation to a limited extent. It can be argued that "networked R&D" component describes the often mentioned research based innovation concept. The second innovation pattern is termed as "production - intensive" since process related effects of innovation and regulation conformance (i.e. process innovations aiming to meet standards or conform to environmental regulations), which basically determine process technologies, have high loadings on this principal component. Firms following this path are also active in new product development. In addition organizational innovation and cooperation also have a bearing on this principal component. "Market driven" pattern brings together marketing innovation and IPR dimensions in addition to organizational innovation and product related effects of innovation. R&D and design & marketing have slight loadings on this principal component. The last principal component is designated as "external oriented" since it combines technology transfer and cooperation. Moreover firms following this pattern are highly sensitive to protecting their intellectual properties through various methods.

Yurtseven and Tandoğan (2012) use clustering techniques to group firms according to their factor scores and identify 5 groups of innovative firms. The first cluster is termed as "high profile innovators" and firms in this group have above average scores in all factors, except the external oriented dimension. Moreover, high profile innovators have the highest average employee figure, which conforms to the idea that larger firms are more active in innovation. High profile innovators, which are active in both product and process innovations, have the second highest innovation investment over sales ratio. Highest sale share of novel goods and services is encountered in the market oriented innovators group. Firms in this group are also active in both product and process innovations. On the contrary, firms in the production intensive innovators group are keener to process innovations. It can be argued that this group is populated with firms, which seek advantage through cost reductions and efficiency increases. External oriented innovators group has above average scores in all dimensions, but principal component pertaining to technology transfer and cooperation is very dominant. Moreover firms in this group have the highest innovation expenditure over sales ratio. A bias towards process innovation is also observed in this group. Consequently, it can be argued that firms in this cluster depend on embodied and disembodied forms of technology transfer to upgrade their production infrastructure. Furthermore above average score in the networked R&D component indicates that acquisition of extramural technology is complementary to the in – house innovative activities of the firms in this group.

Yurtseven and Tandoğan's (2012) distribution of clusters over industries is shown in Figure 9. As mentioned above, clusters based on the identified innovation patterns are viewed as reflections of underlying technological regimes. In this sense, an industry is assumed to be dominated by a specific technological regime, if the share of related cluster exceeds 50% in that industry. Their results show that such dominance is observed only in "electricity, water, and gas supply" industries (NACE code 40-41). Approximately 66% percent of firms in these industries belong to the "production intensive" cluster, whereas "market oriented" firms are not represented in these industries. "High profile innovators" exist in all sectors, except wood, pulp, paper, printing, and publishing industries (NACE code 20-22). High profile innovators are most common in electrical and optical equipment (~24%), and petroleum, chemicals, rubber, and plastic products industries (~23%). However high profile innovators do not constitute the majority in any industry. Low share of high profile innovators, which is predominantly based on the "networked R&D" component, indicates that R&D is an important, yet one of many aspects of the innovation process.

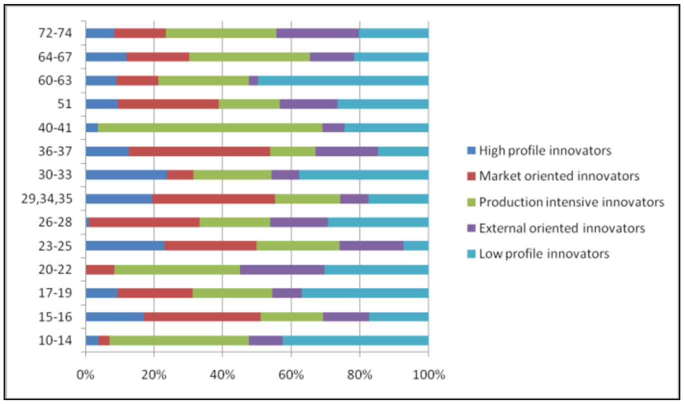


Figure 9 Distribution of clusters over industries (Yurtseven and Tandoğan, 2012)

3.2 Multivariate Statistical Tools

A non-exhaustive list of multivariate statistical techniques that can be used to accomplish research objectives defined in Chapter 2 are listed in Table 3[6]. Table 3 contains an assessment of each method based on their advantages, limitations and their applicability to research objectives handled in this thesis. Selected methods are outlined in subsequent sections[7].

[6] Methods listed in Table 3 cover objectives 1, 2, 3 and 5. Objective 4 – quantification of intra-industry heterogeneity and Objective 6 – innovation – productivity linkage are separately discussed in section 3.4 and 3.5 respectively.

[7]Cluster analysis is not used in this thesis; however a review of clustering methods is given in Appendix – B due to their wide application in the literature.

Table 3 Comparison of multivariate statistical methods

Objective	Suitable Method(s)	Advantage	Disadvantage	Justification
Classification of innovative firms	K-Means clustering	- Ability to handle large data sets faster than hierarchical clustering methods especially if number of clusters is low	- Number of clusters should be determined a priori - Initial clustering centroids affect final cluster structures - Difficulty in comparing the quality of clusters for different number of K - Cannot handle binary or ordinal data efficiently	Not used
	Hierarchical clustering	- Allows for visual representation with dendograms	- Slower in large data sets - Initially incorrectly classified entities cannot be relocated at a later stage - Cannot handle binary or ordinal data efficiently	Not used
	Latent class analysis	- Probability based allocation of entities into groups - Variables can be continuous, categorical, count or any combination of these - Provides parsimony measures to select number of appropriate groups - Can handle missing data	- Slower in large data sets	Latent class analysis method is selected due its ability to handle categorical variables and provide model adequacy metrics (AIC, BIC, $\chi 2$)

Table 3 (continued)

Exploration of innovative patterns	Principal component analysis	- Reduction of number of variables - Identification of inter-related groups of variables	- Cannot handle categorical data directly (tetrachoric or polychoric correlation matrices should be used) - Principle components are affected by the scaling of variables - Principal components are assumed to be uncorrelated; however latent variables in real life problems may be correlated - Number of principal components to retain are generally selected arbitrarily	Not used
	Factor analysis	- Reduction of number of variables - Identification of inter-related groups of variables	- Cannot handle categorical data directly (tetrachoric or polychoric correlation matrices should be used) - Rotation method should be chosen based on a priori research hypothesis, i.e. each rotation method is equally viable in mathematical terms	Principal component analysis attempts to represent the variance in a data set with less number of variables; hence it is suitable for dimension reduction. Factor analysis mainly deals with exploring unobserved latent variables (such as technological regimes).

Table 3 (continued)

Linkage between firm’s resource base and its innovative pattern	Multinomial logistic regression	- Allows for statistical inference - Better suited for describing differences between groups	- Model choice affects predictive power; i.e. all relevant independent variables should be determined beforehand - Correlation between independent variables should be weak - Irrelevant alternatives should be independent, i.e. the odds of belonging to a class over another are independent from the existence or absence of other alternatives.	Not used
	Discriminant analysis	- Allows for statistical inference - Can provide better predictions for small samples (compared to logistic regression)	- MANOVA analysis is required beforehand to test for the existence of group difference - Extremely sensitive to outliers - Independent variables should be normally distributed and variance in each group should be equal - Cannot handle mixed data (continuous and categorical)	Not used
	Classification and regression tree analysis	- Visual representation - Provides “variable importance” metrics which can be used for other analysis - No assumptions about the distribution of variables - Can handle missing data	- Noise in the data can be fit over the model, which can be overcome by pruning (simplifying) the decision tree - Lacks statistical inference tests	Interaction of independent variables is better reflected in classification tree analysis. It does not depend on any assumptions based on data distribution.

Table 3 (continued)

Determinants of intra-industry heterogeneity	Linear regression	- Allows for statistical inference - Goodness of fit statistics can be derived	- Sensitive to outliers, multicollinearity, heteroscedasticity	Used for robustness check
	Classification and regression tree analysis	- Visual representation - Provides “variable importance” metrics which can be used for other analysis - No assumptions about the distribution of variables - Can handle missing data	- Noise in the data can be fit over the model, which can be overcome by pruning (simplifying) the decision tree - Lacks statistical inference tests	Interaction of independent variables is better reflected in classification tree analysis. It does not depend on any assumptions based on data distribution.

3.2.1.1 Latent Class Analysis

Latent class analysis is a statistical technique, which is used to analyze multivariate *categorical* data such as the innovation objectives, information sources, innovation expenditure categories etc. The objective of latent class modeling is to divide the cross classification table of observed (or manifest) variables by an unobserved (or latent) variable, which eliminates all confounding between the manifest variables. Practically latent class model assigns each observation to a group or "latent class", which in turn generates expectations about how that entity shall respond on each manifest variable.

Latent class model can be thought of as a specific type of a finite mixture model, since the unobserved latent variable is unordered categorical. The component distributions in the mixture are cross-classification tables of equal dimension to the observed table of manifest variables, and the frequency in each cell of each component table is the product of the respective class-conditional marginal frequencies. Observations with similar sets of responses on the manifest variables should tend to come together within the same latent classes (Linzer & Lewis, 2011). An outline of terminology and model definition of latent class models is given below.

Let there be J polytomous categorical variables, each of which contains K_j possible outcomes, for individuals $i=1,2,\dots,N$. The observed values of the manifest variables are denoted as Y_{ijk} such that $Y_{ijk}=1$ if entity i has the kth response to the jth variable, where $j=1,2,\dots, J$ and $k=1,2,\dots,K_j$.

The latent class model approximates the observed joint distribution of the manifest variables as the weighted sum of a finite number, R, of constituent cross-classification tables.

Let π_{jrk} denote the class conditional probability such that an observation in class *r=1,2,…,R* generates the kth outcome on the jth variable. Therefore, sum of all the class-conditional probabilities for all possible outcomes equals unity, i.e. $\sum_{k=1}^{K_j} \pi_{jrk} = 1$. Moreover mixing proportions in the component tables are denoted as p_r (Linzer & Lewis, 2011).

The probability that an individual *i* in class *r* produces a particular set of *J* outcomes on the manifest variables, assuming conditional independence of the outcomes *Y* given class memberships, is given in Equation 1:

$$f(Y_i; \pi_r) = \prod_{j=1}^{J} \prod_{k=1}^{K_j} (\pi_{jrk})^{Y_{ijk}} \tag{1}$$

Then the probability density function across all classes is the weighted sum of a finite number of constituent cross-classification tables, which can be calculated according to Equation 2:

$$P(Y_i|\pi, p) = \sum_{r=1}^{R} p_r \prod_{j=1}^{J} \prod_{k=1}^{K_j} (\pi_{jrk})^{Y_{ijk}} \tag{2}$$

Accordingly, latent class model estimates the parameters p_r and π_{jrk}. Given the estimates of p_r and π_{jrk} the posterior probability that each individual belongs to each class, conditional on the observed values of the manifest variables, can be calculated using the Bayesian formula given in Equation 3:

$$\hat{P}(r_i|y_i) = \frac{\hat{p}_r f(Y_i; \hat{\pi}_r)}{\sum_{q=1}^{R} \hat{p}_q f(Y_i; \hat{\pi}_q)} \tag{3}$$

where $r_i \in \{1, \ldots, R\}$.

Latent class analysis, which provides a variety of tools to assess the model fit and determine the appropriate number of classes has a major advantage over other statistical techniques used to cluster multivariate data. Especially for exploratory purposes, analysis can start by fitting a complete independence model with R=1 (i.e. single latent class) then the number of latent classes can be iteratively increased. Increasing the number of groups in the latent class model should increase the fit of the model, together with the risk of fitting to noise. Parsimony criteria aim to mediate a balance between over and under fitting the model to the data by penalizing the log – likelihood by a function of the number of parameters being estimated. Most commonly used parsimony measures are Akaike information criterion (AIC) and Bayesian information criterion (BIC). These criteria are used to compare several plausible models where the lowest value of a given index indicates the best fitting model. In addition to these parsimony measures, Pearson's χ^2 goodness of fit and likelihood ratio chi-square (G^2) can be calculated for the observed versus predicted cell counts. In this case, strategy should be to choose the model that minimizes χ^2 or G^2 without estimating excessive number of parameters.

3.2.2 Factor Analysis

Variability among observed variables within a data set can be described by a lower number of latent variables through factor analysis. Factor analysis is often used as a data reduction tool, which is utilized to eliminate redundancy or duplication from a set of correlated variables. Factor analysis can also be used to explore underlying patterns within the data. Factor analysis method seeks to find joint variations of observed variables in response to unobserved latent variables. These "factors" are modelled as linear combinations of observed variables and the error terms.

Let there be a set of p variables $x_1, x_2,..,x_p$ with means $\mu_1, \mu_2,.., \mu_p$ then the underlying k factors can be modeled as;

$$x_i - \mu_i = l_{i1}F_1 + \cdots + l_{ik}F_k + \varepsilon_i \quad (4)$$

where $i \in 1, \dots p;\ \ j \in 1, \dots, k;\ k < p$

l_{ik} in Equation 4 is a set of unknown constants and ε_i are independently distributed error terms with zero mean and finite variance. This variance may differ for some observations. Let $Var(\varepsilon_i) = \vartheta_i$ then $Cov(\varepsilon) = Diag(\vartheta_i, \dots, \vartheta_p) = \Psi$ and $E(\varepsilon) = 0$. Then in matrix terms;

$$x - \mu = LF + \varepsilon \tag{5}$$

If there are n observations, then the matrix dimensions should be in the form x_{pxn}, L_{pxk} *and* F_{kxn}. In this structure, *L* does not vary across observations. If the following assumptions are imposed;

- *F* and ε are independent
- *E(F)=0*
- *Cov(F)=I*

then any solution to the above set of equations should yield *F* as the factors and *L* as the loading matrix.

Loadings represent the correlation between each variable and factor. Unrotated loading matrix forces the factors to be orthogonal and maximizes variance due to first and subsequent factors. As a result many variables have substantial loadings on more than one factor. Therefore, orthogonal (varimax, quartimax, equimax) or oblique (direct oblimin, promax) rotation methods are applied in order to obtain more comprehensible results. The aim of matrix rotation is to obtain a "simple structure" exhibiting a loading pattern, in which variables have higher loadings on one factor.

3.2.3 Classification and Regression Tree Analysis

Data mining is a broad research area that mainly focuses on data exploration for the purpose of finding previously unknown patterns. Data mining methods can be used for hypothesis verification as well as for exploring new association rules and patterns.

Classification and regression tree analysis (abbreviated as CART) is a discovery oriented data mining technique developed by Breiman et. al. (1984). CART is a tree based classification and prediction algorithm that uses recursive partitioning to split the data into smaller segments with similar output values.

Decision tree construction is a repetitive process and it starts with defining the attribute to be set as the root to start dividing the tree. Attributes can be categorical or continuous. In case of categorical output values, the process yields a classification tree, whereas decision trees based on continuous output values are designated as regression trees. Fundamental steps in building a decision tree can be outlined as follows:

(1) Find the single explanatory variable that “best” splits the data into two groups
(2) Separate the data and repeat (1) on each sub-group recursively
(3) Repeat (2) until the sub-groups reach a minimum size or until no further improvement can be achieved

For a classification problem if a node is split into two so as to obtain two branches, then;

$$P(A_L)r(A_L) + P(A_R)r(A_r) \leq P(A)r(A) \quad (6)$$

where *A* represents some node of the tree, *P(A)* is the probability of *A* and *r(A)* is the risk of node A.

$$P(A) = \sum_{i=1}^{C} \pi_i P\{x \in A | \tau(x) = i\} \approx \sum_{i=1}^{C} \pi_i n_{iA}/n_i \quad (7)$$

where π_i $i = 1,2, \ldots, C$ is the prior probabilities for each class; $\tau(x)$ is the true class of an observation and x is the vector of predictor variables; n_i and n_A are number of observations that belong to class *i* and number of observations at node A respectively.

$$r(A) = \sum_{i=1}^{C} p(i|A) L(i, \tau(A)) \quad (8)$$

where $p(i|A) \approx \pi_i(n_{iA}/n_i)/\sum \pi_i(n_{iA}/n_i)$, τ_A is the class assigned to A if A were to be the terminal node in the tree. Using Equations 6 to 8, splitting points that maximize Δr can be identified and the tree can be constructed accordingly. However splitting the nodes solely based on Δr may yield ambiguous results. Therefore, impurity measures are used to identify splitting points. Let *f* be some form of an impurity function. Then the impurity of node A can be written as:

$$I(A) = \sum_{i=1}^{C} f(p_{iA}) \quad (9)$$

where p_{iA} is the ratio of observations that belong to class i at node A. $I(A)$ should be equal to 0 for $f(0) = f(1) = 0$. Entropy index $f(p) = -plog(p)$ and the Gini index $f(p) = p(1-p)$ satisfy these boundary conditions; hence they can be used to identify splitting points. Accordingly, splits with maximal impurity reduction are used in constructing the tree:

$$\Delta I = p(A)\iota(A) - p(A_L)I(A_L) - p(A_R)I(A_R) \quad (10)$$

3.3 Measuring Heterogeneity

The concept of heterogeneity is at the very core of evolutionary economics, and its quantification is an object of growing interest. However heterogeneity is a multi-dimensional notion and its various aspects should be analyzed in more detail.

A broad definition of “diversity” should be given before further elaborating on its various aspects. Following Harrison and Klein (2007), diversity can be described as the distribution of differences among the members (e.g. firms) of a unit (e.g. sectors) with respect to a common attribute. Building upon this definition, following arguments can be put forward:

- Diversity is specific to the attribute under consideration, i.e. a unit is not diverse per se. It is diverse with respect to one or more specific features of its members.
- Diversity is a unit level construct. Consequently, when diversity is described with respect to a given attribute, unit is described as a whole.

Harrison and Klein (2007) argue that diversity is composed of three elements, namely separation, variety and disparity. Accordingly, separation pertains to the differences in lateral position (such as opinion, values etc.) among unit members whereas disparity is related to the differences in vertical position (resources, assets etc.). On the other hand, variety is described as the composition of categorical differences among unit members. These three aspects of diversity are graphically shown in Figure 10.

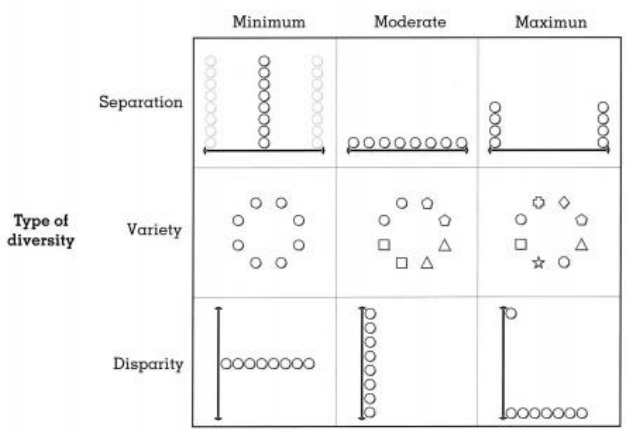


Figure 10 Harrison and Klein's (2007) conceptualization of diversity

Upper-left corner in Figure 10 pertains to a situation, in which all the entities have the same lateral position (e.g. all firms in a sector have the same propensity to innovate). On the hand, upper right corner represents a strict division (e.g. some firms have very high propensity to innovate; whereas some firms are not innovative at all). Middle-left section in Figure 10 displays an instance, in which all the entities belong to the same category (e.g. every member in a project team is engineer).On the contrary, middle-right section shows a state, in which each entity belongs to a different category (e.g. every department is represented in a project team). All entities shown in lower-left corner of Figure 10 share the same vertical position (e.g. all firms in a sector have the same R&D spending); whereas maximum inequality is depicted in the lower-right corner.

According to Harrison and Klein (2007), standard deviation can be a simple measure of separation.

$$Standart\ Deviation = \sqrt{\frac{\sum_i^n (x_i - \bar{x})^2}{n}} \qquad (11)$$

where n is the number of observations.

Harrison and Kline (2007) also recommend using Euclidean distances to quantify separation. The Euclidean distance two points p and q is the length of the line segment connecting them. In n dimensional Cartesian coordinates if $p=(p_1, p_2, \ldots, p_n)$ and $q=(q_1, q_2, \ldots, q_n)$ then the distance from p to q (or vica versa) is given by:

$$\overline{pq} = \sqrt{\sum_{i=1}^{n}(p_i - q_i)^2} \quad (12)$$

Let there be *m* observations. Then the average Euclidean distance would be:

$$Average\ Euclidean\ Distance = \frac{\sum_{j=1}^{m}\sqrt{\sum_{i=1}^{n}(p_i - q_i)^2}}{m} \quad (13)$$

Squared Euclidean distance can be used to assign more weight to observations that are further apart. If squared Euclidean distances are used, separation can be calculated as follows:

$$Squared\ Euclidean\ Distance = \frac{\sum_{j=1}^{m}\sum_{i=1}^{n}(p_i - q_i)^2}{m} \quad (14)$$

Harrison and Kline (2007) relate *variety* to the differences in kind and category. Hence they mostly suggest measures used in ecology to quantify *variety*. One of the most commonly used diversity measure in ecology is the Shannon index, which depends on the idea that the diversity in a system can be measured analogously to the information contained in a code or message assuming observations are randomly sampled from an infinitely large group and all possible categories are represented in the sample (Magurran, 2004). Shannon index is given in Equation 15:

$$Shannon\ Index = -\sum p_i\, ln(p_i) \quad (15)$$

where p_i is the relative abundance of category i and it is estimated as:

$$p_i = \frac{n_i}{N} \qquad (16)$$

n_i in Equation 16 is the number of observations in category i and N is the sample size. Absence of some categories may result in biased estimates for p_i, hence an unbiased estimator of the Shannon index does not exist according to Magurran (2004).

Another commonly used measure is the Simpson index, which gives the probability of any two individuals randomly drawn from an infinitely large sample are identical (Magurran, 2004). Simpson index is given as:

$$Simpson\ Index = \sum p_i^2 \qquad (17)$$

where p_i is the relative abundance of i^{th} category. Formulation in Equation 17 is not suitable for finite samples. Form of the index for a finite sample is:

$$Adjusted\ Simpson\ Index = \sum \frac{n_i(n_i - 1)}{N(N-1)} \qquad (18)$$

in which n_i is the number of observations in category i and N is the sample size.

In fact, Simpson index is identical to Herfindahl index, which is used to estimate the degree of concentration in a market.

Harrison and Klein (2007) define *disparity* as the composition of vertical differences in proportion of socially valued assets or resources and argue that it can be quantified using the coefficient of variation or the Gini index.

Coefficient of variation is a normalized measure of dispersion of a probability distribution, which can be simply calculated by dividing the standard deviation to the mean as shown in Equation 12. When working with a sample from a population, coefficient of variation can be estimated by dividing the sample standard deviation to the sample mean. Coefficient of variation provides a unitless and simple measure for quantifying disparity.

$$Coefficient\ of\ Variation = \frac{\sigma}{\mu} \qquad (19)$$

The Gini index is a measure of inequality among values of a frequency distribution. The Gini index takes the value of 0 for perfect equality and 1 for maximum disparity. The Gini index is easily interpretable and is indifferent to population size, which makes it suitable to compare disparities of populations with different sizes. However the Gini coefficient provides simplicity for the sake of loss of information. For example, two industries may have the same Gini values with respect to an attribute (e.g. size, productivity, R&D expenditure) but sector level average of this attribute can be significantly different when these two industries are compared.

The Gini index is defined as the ratio of the areas of the Lorenz curve, which is the graphical representation of the cumulative distribution function of the empirical probability distribution of an attribute. In this sense, the Gini index can be calculated using Equation 20.

$$Gini\ Index = 1 - 2\int_0^1 L(X)dX \qquad (20)$$

where L(X) represents the Lorenz curve.

Stirling (1998) defines diversity as the “degree of apportionment of a quantity to a set of well-defined categories”, and decomposes diversity into three categories, namely variety, balance and disparity. In this sense, variety refers to the number of categories into which the quantity under consideration can be partitioned and it equals to a positive integer. Balance is related to the distribution of the quantity under consideration across relevant categories and it can be quantified as a set of positive fractions, which sum to unity. Stirling (1998) provides an alternative description for disparity as the degree which categories under scrutiny are different from each other. Stirling's conception of elements of diversity is illustrated in Figure 11.

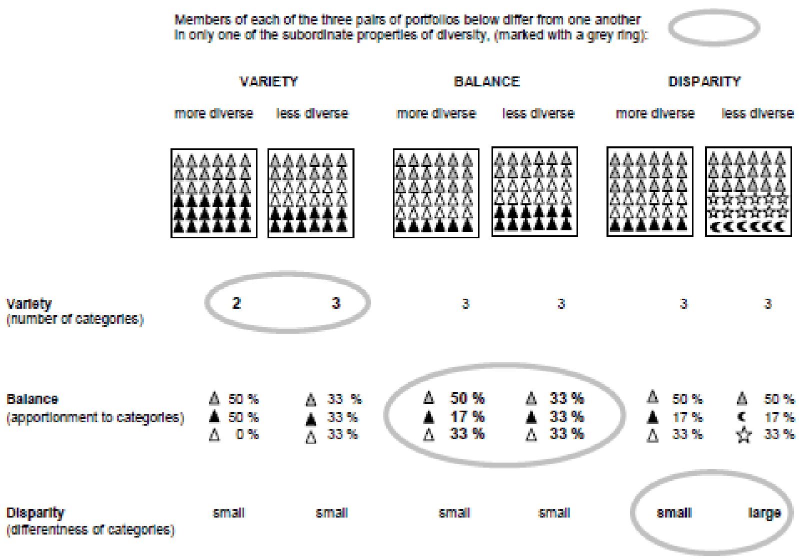


Figure 11 Stirling's (1998) conceptualization of diversity

According to Stirling (1998), variety can be measured by species count, which is basically the number of different categories in a population and species richness, which is the ratio of number of species to the number of entities in a population.

Balance in Stirling's conception can be quantified by Shannon or McIntosh evenness indexes, which are presented in Equations 21 and 22 respectively.

$$Shannon\ Evenness\ Index = \frac{-\sum p_i ln(p_i)}{\ln(S)} \quad (21)$$

$$McIntosh\ Evenness\ Index = \frac{N - \sqrt{\sum_i n_i^2}}{N - N\sqrt{S}} \qquad (22)$$

S in equation 21 is the number of species and the numerator is the Shannon index shown in Equation 17. n_i in McIntosh evenness index is the number of entities in category i and N is the total number of entities.

Stirling (1998) integrates variety and balance in a dual concept, which can be expressed with Equation 23.

$$\Delta_a = \sum_i (p_i^a)^{1/(1-a)} \qquad (23)$$

Δ_a is a generic representation, governed by the relative weight given to variety and balance. Greater values of *a* allocate more weight to balance. For example Δ_0 is identical to species count, whereas when *a* is set to 1, Equation 23 turns into Shannon index, which is given in Equation 17. It is possible to obtain the reciprocal of the Simpson index from Equation 23 by setting *a* to 2.

Harrison and Klein's (2007) definition of "variety" corresponds to Stirling's (1998) definition of "balance", whereas description of "disparity" in the latter resembles to the explanation of "separation" in the former.

This thesis is mainly concerned with diversity of innovation patterns within industries; therefore *variety* based metrics, which depend on relative proportion of different groups within a unit, better suit the research objectives. Separation based metrics, which quantify the relative position of entities within a unit, should also be used to add robustness to analysis. On the other hand, effects heterogeneity due to inequal distribution of some attributes on the innovation process is beyond the scope of this thesis. Consequently, variety and separation based diversity metrics are used in the subsequent analyses.

3.4 Innovation and Productivity

Investigation of the relationship between innovative activities and productivity has been a major area of interest in economics. These efforts to understand and quantify the effects of innovative activities on productivity and productivity growth can be attributed to the common belief that innovation is the key component of long term economic growth and sustaining competitive advantage. Number of studies on productivity, particularly at the firm level has been increasing in recent years due to availability of comprehensive data sets at the firm level. However quantifying the effects of innovation on productivity is a cumbersome task. Peters (2008) reports that despite the large number of studies examining this relationship, only a number of them have been successful.

This difficulty mainly stems from the hurdles pertaining to adequately measuring innovation. For a long period of time empirical studies focused on input – oriented innovation indicators such as R&D expenditure and R&D intensity. These studies generally followed a production function approach and used R&D expenditure (or other indicators derived from R&D expenditure) as an input factor. However it is well known that R&D is not the only way for a firm to introduce new products and processes. Moreover output of innovative activities, i.e. new products and processes are more decisive on firm performance than the amount of allocated resources to achieve them. Treating the mechanism, which transforms resources allocated to innovation into new products and processes as a black box may lead to erroneous or over simplified deductions. On the other hand, firms undertaking innovative activities do not constitute a random sample in a given data set; hence a restriction to the selected (innovative) sample may induce biased estimates (Heckman, 1979). Crépon, Duguet and Mairesse's (1998) influential study paved the way to overcome aforementioned methodological deficiencies. Their empirical model, abbreviated and referred to as CDM model in the literature, connects innovation input, innovation output and productivity.

3.4.1 Input and Output Measures in the Innovation Process

R&D expenditure and patent applications are traditional measures of innovation input and output respectively. Numerous countries collect R&D expenditure data on an annual basis, following the instructions of OECD's Frascati Manual. On the other hand, patent statistics dating back to 19th century are available in many countries. However these measures suffer from a number of caveats. First, R&D expenditure is one of the many inputs used in the innovation process. Moreover, R&D expenditures generally include labor, capital and material costs, which may be counted twice unless expenditures in these items are separated from their R&D component (Hall, Mairesse, & Mohnen, 2009). On the other hand, patent data provides information about innovations that are deemed worthy for patent application, yet most of the patented inventions are never introduced to markets (Mairesse & Mohnen, 2010).

Availability of firm level data has made it possible to explore the relationship between innovation and productivity in more detail. SPRU database, which contains information about 4.000 technical innovations commercialized between 1945 and 1983 in the United Kingdom, is a pioneering example of such firm level data set. Using this data set, Pavitt et. al (1987) show that there is an inverted U shape relationship between firm size and innovative activity. Geroski (1989) also utilizes the SPRU database and claims that distributed lag of innovation is more important than entry in total factor productivity growth. Moreover Sterlacchini (1989) seeks for a relationship between R&D and SPRU innovations with respect to industrial affiliation.

Acs and Audretsch (1990) compile more than 8.000 innovations introduced in the United States in 1982 by surveying a large number of trade journals for the

United States Small Business Administration. Acs and Audretsch utilize this data to analyze the role of small firms in the innovation process, their growth characteristics and the evolution of market structure. Unit of observation in both of these databases is “innovation”; hence firm level data is obtained by aggregating these innovations. Consequently, these data sets focus only on innovative firms; hence selection bias is inevitable.

OECD and EUROSTAT’s collaborative efforts to develop standardized innovation output measures in the early 1990’s resulted in the emergence of harmonized innovation surveys, which are commonly referred to as Community Innovation Surveys in Europe. OECD’s Oslo Manual, of which first version had been published in 1992 and later revised in 1996 and 2005, defines various ways of innovation and provides a methodological framework to quantitatively measure input and output items in the innovation process. Innovation surveys were carried out at four year intervals up to the third revision of the Oslo Manual and each survey was named after the round. CIS1 covers the period of 1990-1992, whereas CIS2 contains information about innovative activities performed between 1994 and 1996. Innovation surveys have been conducted at two year intervals since 2007 and they are named after their reference year (i.e. CIS2006 for the period 2004-2006). According to Godin (2002)primary objective of early innovation surveys, conducted in accordance with the Oslo Manual, is to develop output measures whereas recent focus is on measuring the quality and quantity of various innovation activities.

Turkish Statistical Institute, in collaboration with the Scientific and Technological Research Council of Turkey, conducted the first innovation survey in Turkey, which was compatible with CIS2, covered the period of 1995-1997 and directed to firms from manufacturing and some selected service sectors. Following this initial attempt, another innovation survey was conducted in 2002 in accordance with CIS3 covering the three year period of 1998-2000. Turkish Statistical Institute performed another innovation survey in 2005 to capture the innovative activities between 2002 and 2004. Innovation surveys compatible with CIS2006, CIS2008 and CIS2010 were implemented in 2007, 2009 and 2011 respectively.

R&D expenditure is generally accepted as the main input in the innovation process. Schumpeter's Mark II model correlates firm size and the rate of its innovative activity positing that larger firms are more innovative than smaller firms. There are several arguments supporting this deduction. First, larger firms have easier access to external financial sources and they can provide larger and more sustainable internal funds. Moreover larger firms can create economies of scale in their R&D investments. Finally larger firms can support their R&D activities with their enhanced management, marketing and sales functions. Numerous studies show that the incentive to innovate increases with firm size (Cohen & Levin, 1989; Cohen & Klepper, 1996; Pamukcu, 2003; Klette & Kortum, 2004).

Market power may also create a strong incentive for innovation, since additional monopoly rents can be obtained from novel products and processes. Moreover uncertainty due to competition and excessive rivalry can be reduced. Both positive and negative correlation of market concentration and R&D investment are reported in the literature. For example Cohen, Levin and Mowery (1987) report a positive relationship between market power and R&D expenditure, whereas Blundell, Griffith and van Reenen (1999) suggest that competition provides a strong incentive for innovation.

Patent counts (and more recently patent value indicators based on expert opinions, renewals, citations etc.) have been extensively used as output indicators. Various studies report a positive relationship between research investment and patenting performance (Pakes & Griliches, 1984; Tratjenberg, 1990; Crépon, Duguet, & Mairesse, 1998). Empirical studies show that patent data is highly skewed. Moreover patenting behavior is different among sectors.

Political conditions also affect patenting performance of firms. For example Hall and Ziedonis (2001)

Innovation surveys allow quantification of innovation output in the form of share of sales related to new products. However Mairesse and Mohnen (2010) argue the subjectivity of this indicator and suggest that it should be used as a categorical variable. Respondents tend to provide rounded (and often highly inaccurate) values for this variable, since the definition of new or significantly improved product is not clear. Yet many empirical studies make use of this variable as an indicator of innovation output.

3.4.2 Measuring Productivity

Productivity describes the relationship between output and inputs, which are required to generate that output. Accordingly output can be measured by gross output, value added or sales. Value added can be defined as the output obtained from the combined use of capital and labor. Thus value added can be calculated by subtracting the value of purchased inputs from the gross output. On the other hand, sales can be used as a proxy for gross output, since it can be calculated by subtracting the value of inventory increase in finished goods from the gross output. Major productivity measures based on different input and outputs are outlined in Table 4. Productivity can be measured in order to gain insight about the following parameters (Schreyer & Pilat, 2001).

- Technological change: Productivity growth can be measured to trace technical change. Explicit and implicit forms of technology can be incorporated in the productivity measurements.
- Efficiency: Full efficiency in a system indicates that a production process has yielded the maximum amount of output that is physically attainable with given inputs and technology. In this sense, technical efficiency

changes can be attributed to a movement towards the best practice, or elimination of technical and organizational inefficiencies.

- Real cost savings: Productivity is generally measured residually and this residual includes changes due to technological developments and efficiency gains in addition to changes related to capacity utilization, learning effects and measurement errors.
- Benchmarking production processes: Comparing productivity measures for different production processes can be instrumental in identifying inefficiencies. Highly specific productivity measures such as cars-per-day, or passengers-per-hour allows one on one comparisons.
- Living standards: Income per capita in an economy is directly related to value-added per hour worked. Hence labor productivity can be used to assess the standards of living in an economy.

According to Hall et al. (2009), choice of productivity measure depends on availability of data rather than methodological concerns.

Table 4 Main productivity measures (Schreyer & Pilat, 2001)

Type of output measure	Type of input measure			
	Labor	Capital	Capital and labor	Capital, labor and intermediate inputs (materials, energy, services)
Gross output	Labor productivity (based on gross output)	Capital productivity (based on gross output)	Capital-labor MFP (based on gross output)	KLEMS MFP
Value- added	Labor productivity (based on value-added)	Capital productivity (based on value-added)	Capital-labor MFP (based on value-added)	
	Single factor productivity measures		Multi-factor productivity measures	

3.4.3 Linking innovation with productivity

Endogenous growth theory suggests that investment in research, knowledge and human capital is positively correlated to economic growth (Romer, 1986;

1990). Many of the empirical studies overviewed by Mairesse and Sassenou (1991), Griliches (1995) and Bartelsman and Doms (2000) employ an augmented Cobb-Douglas production function as shown in Equation 24[8].

$$Q = AL^{\alpha}C^{\beta}M^{\delta}K^{\gamma}e^{\mu} \tag{24}$$

Q denotes output, whereas L, C and M refer to conventional input factors of labor, capital and materials (including raw materials and energy). Knowledge capital, K, is included as an additional input factor to the production function. Error term captures stochastic variations in productivity. Log transformation of both sides yields Equation 25.

$$q = a + \alpha l + \beta c + \delta m + \gamma k + \mu \tag{25}$$

Equation 25 can be simplified by writing the terms in growth in labor productivity (and capital productivity per employee etc.). If conventional inputs in Equation 25 have constant returns to scale (i.e. $\alpha + \beta + \delta = 1$), then it can be written as follows:

$$q - l = (\alpha + \beta + \delta - 1)l + \beta(c - l) + \delta(m - l) + \gamma k + \mu \tag{26}$$

Equation 26 can be arranged to account for growth rates as shown in Equation 27:

$$\Delta(q - l) = (\alpha + \beta + \delta - 1)\Delta l + \beta\Delta(c - l) + \delta\Delta(m - l) + \gamma\Delta k + \Delta\mu \tag{27}$$

Knowledge capital can be calculated using the perpetual inventory method. However this method requires R&D expenditures to be known for a significantly long time span and appropriate deflators are needed to convert nominal R&D expenditures to real values. Moreover a depreciation rate should be adopted.

[8] Time and entity indices have been dropped for easier representation

Some researchers use rate of return to R&D ($\rho = \gamma Q/K$), instead of its elasticity. If depreciation of knowledge capital is omitted, then Equation 27 can be written as:

$$\Delta(q-l) = (\alpha + \beta + \delta - 1)\Delta l + \beta\Delta(c-l) + \delta\Delta(m-l) + \rho r + \eta \qquad (28)$$

Equation 28 incorporates rate of return to R&D instead of its elasticity and R&D intensity instead of R&D capital. Griliches (1986) uses this framework to analyze the contribution of basic and applied research investments to productivity growth of roughly 1.000 manufacturing firms between 1957 and 1977 and reports that basic research contributed more to productivity growth than other types of research. Output elasticity of R&D capital ranges between 0.06 and 0.20; whereas rate of return values of 0.20 to 0.50 have been reported in the literature (Griliches, 1998).

Production function approach, which has been extensively used in the literature, bears some caveats as well. For example Griliches (1995) argues that estimated return to R&D in the USA is lower than actual values, since spill-over effects of R&D are disregarded in some studies. According to Hall and Mairesse (1995) variables in the right hand side of Equation 27 are under the control of firms and they can be determined simultaneously with the output level, implying input variables and the error term in Equation 27 are correlated. Moreover selection bias related to non R&D performers in the data set is seldom corrected. Crépon, Duguet and Mairesse (1998) propose a framework, which is based on the model developed by Pakes and Griliches (1984), in order to deal with selection and simultaneity issues.

Overall structure of the CDM Model is shown in Figure 12. CDM Model, which simultaneously takes into account various aspects of the innovation process, consists of three stages and four recursive equations. CDM Model has a basic and extended specification, in which output indicators are patent count and share of innovative sales respectively. Moreover, technology push and demand pull variables are included in the extended model.

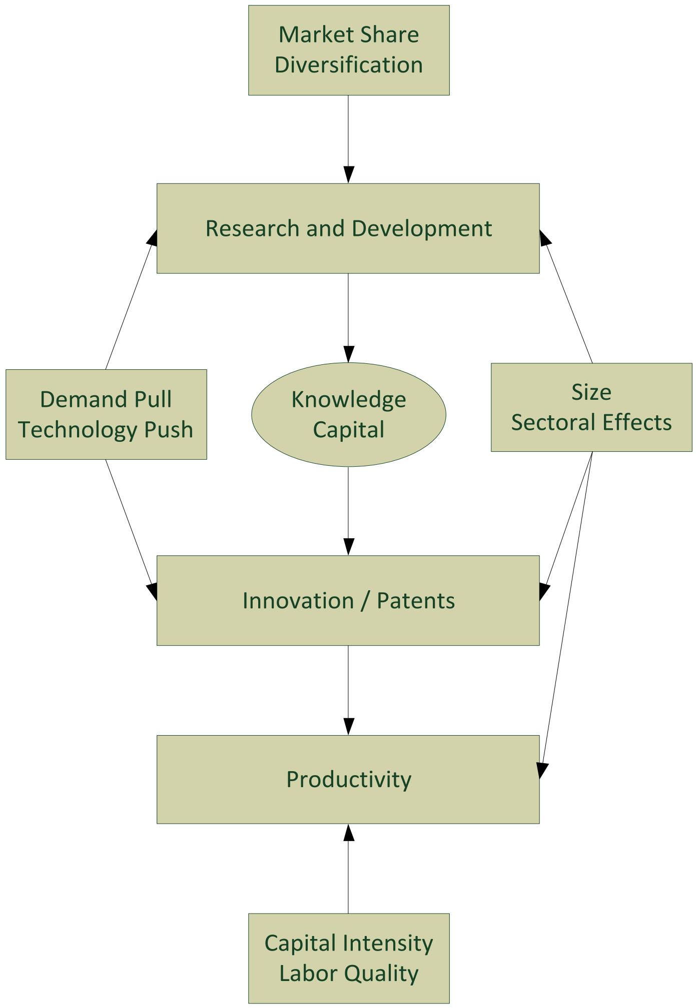


Figure 12 Flow diagram of the CDM Model

Crépon, Duguet and Mairesse (1998) apply this model to the 1990 French Manufacturing Survey on Innovation covering 6.145 manufacturing firms. Their results indicate that larger firms with more market power and diverse product portfolio are more prone to engaging in R&D activities. However research intensity is inversely proportional to firm size. Moreover R&D intensity is positively associated with both innovation output indicators, namely patent count and share of new products. Estimation results pertaining to the final stage of the model show that innovation output contributes to labor productivity. Availability of firm level harmonized innovation survey data has enabled the application of CDM model extensively. A non-exhaustive chronological outline of such studies is given in Table 5. Lööf and Heshmati’s study (2006) is of particular interest in this list, since their econometric methodology (using instrumental variable regression instead of asymptotic least squares regression to overcome simultaneity issues) is also employed in this thesis.

Studies listed in Table 5 generally suggest a positive relationship between innovation and productivity. However Griffith et. al. (2006) cannot verify the positive impact of process innovation on productivity except for France. Benavante (2006) reports neither research investment nor product innovations contribute to higher productivity in Chile. These studies focus on the effects of firm size (Hall et. al., 2009) or firm’s organizational structure, i.e. foreign affiliation, being part of a conglomerate etc. (Raffo et. al., 2008) on productivity or cross-country comparisons (Lööf et. al., 2001; Janz et. al., 2003; Griffith et. al., 2006). However none of the studies cited in Table 5 consider the effects of intra-industry heterogeneity of innovative behavior on firm performance.

Woerter (2009) constructs a diversity metric based on the average Euclidean distance of firms within a sector based on their R&D spending intensity, share of export revenue over total sales, firm size (proxied by the number of employees) , and share of staff with higher education. Using data from 4.050 firms (2.539 of which are denoted as innovative) from Germany, a random effects Tobit model is estimated to investigate the relationship between intra-industry heterogeneity and firm performance, which is defined as the share of revenue due to new products over total sales. Woerter (2009) reports a positive correlation between intra – industry heterogeneity and firm performance.

Table 5 Outline of empirical studies using the CDM framework

Author(s)	Country	Data	Period	Estimation Method	Innovation Output Measure	Productivity Measure	Main Findings
(Lööf, Heshmati, Asplund, & Naas, 2001)	Finland, Norway, Sweden	CIS2 – manufacturing firms (FI: 1.062, NO: 1.315, SE:745)	1994 – 1996 (1995 – 1997 for Norway)	Modified CDM with Tobit model for selection, 3SLS for innovation output and productivity	Logarithm of sales related to new products Process innovation dummy	Logarithm of sales per employee	Higher elasticity of knowledge in production function for Norway, contradicting the initial expectations since Sweden and Norway have higher aggregate productivity growth and R&D intensity
(Janz, Lööf, & Peters, 2003)	Germany, Sweden	CIS3 – manufacturing firms (DE: 574, SE: 474)	1998 - 2000	Modified CDM with Tobit model (full maximum likelihood) for selection, 2SLS for innovation output and productivity	Logarithm of sales related to new products	Logarithm of sales per employee	Innovation input and output intensities decrease with firm size in Germany. Elasticity of labor productivity with respect to innovation output is similar in both countries

Table 5 (continued)

(Chudnovsky, Lopez, & Pupato, 2006)	Argentina	INDEC – SECYT 1992-1996 INDEC – SECYT 1998 2001 (panel of 718 manufacturing firms)	1992 – 1996 1998 – 2001	Modified CDM with fixed effects estimation for productivity	Product and process innovation dummies and their interactions	Logarithm of sales per employee	No correction for selection bias. Total innovation expenditure intensity is used rather than research intensity. R&D increases probability for product innovation; whereas technology acquisition increases the probability for both product and process innovation
(Jefferson, Huamao, Xiaojing, & Xiaoyun, 2006)	China	Large and Medium Size Enterprise Survey – Approximately 20.000 manufacturing firms for each year	1995 - 1999	Modified CDM with sequential instrumental variable regression	Logarithm of sales related to new products	Profitability Logarithm of output per employee	No correction for selection bias is reported. Reported rate of return for R&D is much higher than investment to fixed capital

Table 5 (continued)

(Griffith, Huergo, Mairesse, & Peters, 2006)	France, Germany, Spain, United Kingdom	CIS3 – manufacturing firms (FR: 3.625, DE: 1.123: ES: 3.588, UK: 1.904)	1998 - 2000	Modified CDM with sequential instrumental variable regression	Product and process innovation dummies	Logarithm of sales per employee	Product and process innovations are estimated as separate probit equations. Process innovation is only associated with higher productivity in France; in the other countries there is no such connection. Product innovation is associated with higher productivity in France, Spain, and the UK, but not in Germany
(Benavante, 2006)	Chile	Chilean Innovation Survey – 438 manufacturing firms	1995 - 1998	CDM model with asymptotic least square regression	Logarithm of sales related to new products	Logarithm of value added per employee	Neither research expenditure nor innovation has a significant impact on innovation sales and productivity.

Table 5 (continued)

(Lööf & Heshmati, 2006)	Sweden	CIS3 – 3.190 manufacturing, service and utility firms	1996 - 1998	Modified CDM with Tobit model for selection, 3SLS for innovation output and productivity	Logarithm of sales related to new products	Logarithm of value added per employee	Simultaneity issues greatly affect estimation results. Value added is a more appropriate measure for performance analysis. Products new to the firm positively affect productivity level; whereas products new to the market are positively associated with productivity growth
(Raffo, Lhuillery, & Miotti, 2008)	France, Spain, Switzerland, Argentina, Brazil, Mexico	CIS3 – (FR:4618, ES: 3559, CH: 925, AR: 1308: BR: 9452, MX: 1515)	1998 – 2000 (1998-2001 for Argentina and Switzerland, 1999 – 2000 for Mexico, 2002 – 2004 for Spain)	Modified CDM with sequential instrumental variable regression	Product innovation dummy	Logarithm of sales per employee	Firms belonging to a conglomerate are more productive. However their R&D intensity is higher than independent firms only in Brazil and France.

Table 5 (continued)

(Masso & Vahter, 2008)	Estonia	CIS3 – 1.467 manufacturing firms CIS4 – 992 manufacturing firms	1998-2000 (CIS3) 2002-2004 (CIS4)	Modified CDM Bivariate probit model for product and process innovations	Product and process innovation dummies	Logarithm of sales per employee	Product innovations positively affect productivity in 1998-2000 period, whereas process innovations contribute to productivity in 2002 – 2004 period. Difference is attributed to macroeconomic conditions in Estonia
(Hall, Lotti, & Mairesse, 2009)	Italy	MCC Survey on Manufacturing Firms (Unbalanced : 7375 firms, balanced: 361 firms)	1995 – 1997 1998 – 2000 2001 - 2003	CDM with four different types of innovation for knowledge production function	Product and process innovation dummies and their interactions	Logarithm of sales per employee	Both product and process innovation have a positive effect on productivity.

3.5 Data

OECD and EUROSTAT's collaborative efforts to develop standardized innovation output measures in the early 1990's resulted in the emergence of harmonized innovation surveys, which are commonly referred to as Community Innovation Surveys in Europe. OECD's Oslo Manual, of which first version had been published in 1992 and later revised in 1996 and 2005, defines various ways of innovation and provides a methodological framework to quantitatively measure input and output items in the innovation process. Innovation surveys were carried out at four year intervals up to the third revision of the Oslo Manual and each survey was named after the round. CIS1 covers the period of 1990-1992, whereas CIS2 contains information about innovative activities performed between 1994 and 1996. Innovation surveys have been conducted at two year intervals since 2007 and they are named after their reference year (i.e. CIS2006 for the period 2004-2006). According to Godin (2002) the primary objective of early innovation surveys, conducted in accordance with the Oslo Manual, is to develop output measures whereas recent focus is on measuring the quality and quantity of various innovation activities.

Turkish Statistical Institute, in collaboration with the Scientific and Technological Research Council of Turkey, conducted the first innovation survey in Turkey, which was compatible with CIS2, covered the period of 1995-1997 and directed to firms from manufacturing and some selected service sectors. Following this initial attempt, another innovation survey was conducted in 2002 in accordance with CIS3 covering the three year period of 1998-2000. Turkish Statistical Institute performed another innovation survey in 2005 to capture the innovative activities between 2002 and 2004. Innovation surveys compatible with CIS2006, CIS2008 and CIS2010 were implemented in 2007, 2009 and 2011 respectively. Distribution of innovative firms according to sectors and size groups is presented in Table 6.

Table 6 Ratio of innovative firms

	Reference Year			
	2004	2006	2008	2010
Sector				
Mining and Quarrying	31,6%	25,1%	22,7%	19,6%
Manufacturing	34,8%	35,7%	34,7%	36,9%
Electricity, Water and Gas Supply	24,5%	27,5%	17,8%	25,7%
Services	25,9%	24,6%	23,2%	33,8%
Size (according to number of employees)				
10-49	31,2%	29,7%	27,8%	32,8%
50-249	46,2%	37,2%	38,4%	44,2%
250	56,3%	43,5%	48,6%	55,9%

(Source: Turkish Statistical Institute)

At the beginning of this thesis research, all four Innovation Survey data sets were made available by Turkish Statistical Institute. However Innovation Survey with reference year 2010 (IS2010) could not be utilized since firms were grouped according to NACE Rev.2, whereas NACE Rev 1.1 was used in previous innovation surveys. EuroStat provides correspondence tables related to the transition from NACE Rev 1.1 to NACE Rev 2. However a single class in NACE Rev 2 may correspond to multiple classes in NACE Rev 1.1 and vica versa. For example 4 digit code of 1107 in NACE Rev 2 (Distilling, rectifying and blending of spirits) may refer to sectors 1591, 1592 and 5134 in NACE Rev 1.1. IS2010 was discarded in order to preserve the internal consistency of the remaining data. Therefore, analysis in this thesis is based on the firm level data from three waves of Turkish Innovation Surveys pertaining to periods 2002 – 2004 (IS4), 2004 – 2006 (IS2006) and 2006 – 2008 (IS2008). Following the 3rd edition of the Oslo Manual, Turkish Statistical Institute uses a harmonized questionnaire to collect data. First section of the questionnaire is designed to gather general firm characteristics like the legal title, foreign share and the markets in which the firm is active. Section 2 and 3 are devoted to questions regarding product and process innovations. Section 4 collects data about ongoing or abandoned innovation activities. Questions in sections 5, 6, and 7 are directed only to innovating firms. Variety and amount of innovation expenditures, sources of knowledge, institutional and spatial characteristics of cooperation, and the impact of innovative activities are reported in these sections respectively. Section 8 collects data about halted and abandoned innovation projects in addition to an assessment of barriers to innovation, whereas section 9 gathers data about the variety of intellectual property rights protection methods pursued by firms. The last section, which has been integrated to the survey according to the recommendations in the 3rd edition of the Oslo Manual, is related to organizational and marketing innovations. Questions related to the barriers to innovation and intellectual property protection methods were dropped in the 2008 Innovation Survey; hence it was not possible to incorporate these variables into the empirical analyses. Moreover IS2008 uniquely contains data about innovations with environmental benefits. Structures of these three data sets, in addition to Innovation Survey 2010, are outlined in Table 7.

Table 7 Structure of different innovation surveys from 2004 to 2010

	IS4	IS2006	IS2008	IS2010
Section 1	General information about the surveyed firm such as primary markets, group affiliation and foreign ownership			
Section 2	Information about product (good or service) innovations. Source of the product innovation is questioned. Novelty of the innovation is surveyed at the market and/or firm level.			Information about product (good or service) innovations. Sources of the goods and/or service innovation are questioned. . Novelty of the innovation is surveyed at the market and/or firm level. Country/world first innovations data is also gathered.
Section 3	Process innovation data about new manufacturing methods, logistic or maintenance/operation systems is gathered. Source of the process innovation is questioned.		Process innovation data about new manufacturing methods, logistic or maintenance/operation systems is gathered. Source of the process innovation is questioned. Novelty of the innovation is surveyed at the market level.	
Section 4	Data about ongoing and/or abandoned innovation activities are gathered.			
Section 5	Data about types of innovation expenditure (in-house R&D, extramural R&D, machinery/software acquisition, external knowledge acquisition, training, market introduction and other innovation activities), actual innovation spending and receipt of financial aid from local authorities, central government, international bodies etc.			
Section 6	Data about sources of knowledge (internal, market related, institutional and other sources) is gathered. Type of cooperation partner (such as other group enterprises, clients, suppliers, universities, public research institutes etc.) and their location is questioned.			
Section 7	Effects of product and process innovations (product oriented, process oriented and other effects) are surveyed.		Importance attached to the objectives of product and process innovations are questioned.	
Section 8	Obstacles to innovation and reasons not to innovate are questioned.		Types of organizational innovations pursued by the firm and the importance attached to the objectives of organizational innovations are surveyed.	Obstacles to innovation and reasons not to innovate are questioned.
Section 9	Methods used to protect intellectual property rights are surveyed.		Types of marketing innovations pursued by the firm and the importance attached to the objectives of organizational innovations are surveyed.	Types of organizational innovations pursued by the firm and the importance attached to the objectives of organizational innovations are surveyed.
Section 10	Types of organizational and marketing innovations pursued by the firm and the importance attached to the effects of such innovations are surveyed.		Innovations with environmental benefits, reasons to introduce innovations with environmental benefits are questioned.	Types of marketing innovations pursued by the firm and the importance attached to the objectives of organizational innovations are surveyed.
Section 11	Basic economic information such as the amount of sales and number of employees in the reference year.			Creativity related skill set of both in-house employed and outsourced personnel are surveyed.
Section 11	N.A.			Basic economic information such as the amount of sales and number of employees in the reference year. Proportion of employees with a university degree is surveyed.
Industrial classification	NACE Rev 1.1			NACE Rev.2

3.6 Linking Theory with Practice

The ability to distinguish between genomes is fundamental in many disciplines such as taxonomical research, phylogenetic studies and population genetics. Genetic characterization is commonly used to classify organisms (van Belkum et al., 2001). In the socio-economic domain, Winter (1971) suggests that decision rules are analogous to genes in molecular biology. According to Winter (1964) a routine is a behavioral pattern that is executed repeatedly, but is subject to change depending on the alteration of conditions. Teece and Pisano (1994, p. 541 and 545), Grant (1996, p. 115), Teece et. al. (1997, p. 518) and Dyer and Singh (1998, p. 665) also analyze the notion of routines as patterns. In his literature review of the concept of routines, Becker (2004) reports that the terms action, activity, behavior and interaction are commonly used to denote the content of patterns and concludes that all these alternative terms are "instances" of activity. Therefore, Becker (2004) suggests that routines can be understood as "patterns of activity". Moreover an activity pattern should be observed more than once for it to be considered as a routine (Winter, 1990).

Peters (2009), who conducted her research on a panel of German firms, reports that approximately 90% of innovating firms maintained their innovative activities in the subsequent period; whereas 84% of non-innovative firms remained inactive in the following period. On the other hand, her findings indicate that almost half of the firms changed their innovative behavior at least during one period under consideration. Consequently, it can be argued that innovative activities of firms can be regarded as routines since they display certain patterns and they are persistent over time.

Building upon this theoretical premise, innovative actions of firms are assumed to be analogous to "genes" in the biological domain. Therefore, it is argued that classification of firms based on these innovative actions is parallel to a phylogenetic taxonomy of organisms. As shall be discussed in sub-section 4.2.2, a taxonomy of innovative firms was constructed by using the latent class analysis technique.

Firms, which experience similar incentives or constraints, may exhibit similarities in their actions. Evolutionary economic theory suggests that firms differ in terms of their innovative behavior. Firms, which are boundedly rational, develop new skills and advance largely through local search (Leiponen & Drejer, What exactly are technological regimes? Intra-Industry heterogeneity in the organisation of innovation activities, 2007). On the other hand, firms operating in the same environment may opt for different strategies if their landscape entails enough complexity (Levinthal, 1997).

Early studies on technological regimes (Nelson & Winter, 1982; Pavitt, 1984) posit that innovative behavior of firms is largely determined by the technological regime in which they operate. Moreover these studies suggest that such technological regimes are industry specific, due to idiosyncratic technological opportunities and knowledge conditions. On the other hand, the strategic management literature (Wernerfelt, 1984; Barney, 1986; Dierickx & Cool, 1989; Teece & Pisano, 1994; Teece, Pisano, & Shuen, 1997) explicitly argues that firms within an industry may purposefully differentiate themselves from their competitors in order to cope with competitive pressure.

Innovation is a complex phenomenon, thus a firm's innovation strategy is expected to have multiple dimensions. Although earlier studies mainly focused on R&D spending (or R&D intensity) and patent counts as the main input and output indicators of a firm's innovative behavior (Hagedoorn & Cloodt, 2003), availability of CIS data made it possible to carry out detailed studies related to the determinants of innovation behavior of firms. As shown in Table 7, several variables can be used to describe the relevant dimensions of the innovation process. Therefore, patterns of innovation in Turkish firms can be explored with a sense that a number of latent variables may exist, which can be used to form a multi-dimensional framework.

Strategic management literature suggests that firms' resource endowments, core competences and capabilities, their knowledge base and position within a network define their innovative behavior. Therefore, classification tree technique was used to predict the related innovation class, using explanatory variables such as innovation expenditure per employee and total number of employees (resource based view of the firm), importance attached to various knowledge sources (knowledge based view of the firm) and cooperation with different parties (relational based view of the firm).

As outlined in section 3.3, there are various metrics to measure biodiversity. Upon identifying different groups of innovative firms and innovation modes, these measures were used to quantify the amount of heterogeneity within industries. In an evolutionary framework, a population consists of selection units with varying characteristics. Selection mechanisms operate on these characteristics, virtually creating a fitness score. Relative importance of selection units change with respect to their fitness scores. Accordingly it can be argued that units with alike traits should obtain comparable fitness scores; thus similar units should survive upon selection. Therefore, it can be argued that factors that are related to the selection process reduce heterogeneity, while those associated with variety generation should have a positive effect on heterogeneity. Regression tree method was employed to explore the determinants of intra-industry heterogeneity. Classification and regression tree algorithms can provide variable importance metrics, based on the contribution each explanatory variable makes to the construction of the tree. Based on these metrics, relevant variables were chosen and fixed effects time series models were estimated for verification purposes.

According to Jacobs (1969) flow of complementary knowledge among heterogeneous firms and economic actors stimulate knowledge spillovers between spatially proximate firms and enhance their innovative performance. Therefore, it can be argued that a sector populated with heterogeneous firms in terms of innovative characteristics may provide a more suitable environment for exchange of knowledge thereby fostering productivity of firms benefiting from such knowledge spillovers. Effects of intra-industry heterogeneity on the innovation process were investigated by estimating a variant of the CDM model. Overall mapping of the theoretical background used in this thesis to the analytical methods is outlined in Table 8.

Table 8 Mapping the theoretical domain to practice

Research objective	Theoretical Background	Application of Theory to Practice	Analytical Technique	Research Output
(1) Classification of innovative firms	- Nucleotide sequence of DNA genome is used to classify organisms in genetics. - Routines are analogous to “genes” in the socio-economic domain. - Innovative activities such as pursuing product or process innovations, investments decisions etc. can be regarded as “routines” since they display a pattern and they are persistent over time.	- Firms is chosen as the unit of analysis - 15 binary variables pertaining to various innovative activities of firms are used to classify firms	- Latent class analysis: Response patterns are used to estimate latent class membership probabilities	- Taxonomy of innovative firms

Table 8 (continued)

(2) Exploration of innovation patterns	- Firms operate on “natural trajectories” or in “technological regimes”, which defines their course of actions. - Early studies suggest that technological regimes are industry specific due to common knowledge basis and similar incentives for innovation. - Recent empirical studies show that multiple innovation patterns exist within industries.	- Firm is chosen as the unit of analysis - 15 binary variables pertaining to various innovative activities of firms are used to identify underlying technological regimes	- Factor analysis: Polychoric correlations between 15 binary variables are used to estimate principal component factors	- Modes of innovation

Table 8 (continued)

(3) Prediction of group membership based on resource endowments, knowledge sources and network embeddedness	- Firms within the same line of business may opt for different strategies based on their resources (tangible and intangible assets), knowledge sources and their relations with other firms and institutions.	- Firm is chosen as the unit of analysis - Variables reflecting the resource endowment of firms such as firm size and R&D intensity, sources of knowledge in addition to type and breadth of cooperation are used to predict group membership	Classification tree analysis Output attribute is the innovative group variable obtained in (1). Explanatory variables are R&D intensity, firm size, breadth and type of knowledge sources, breadth and type of cooperation.	- Group membership predictions - Firm level determinants of intra – industry heterogeneity

Table 8 (continued)

(4) Quantification of intra-industry heterogeneity of innovative strategies	- Various measures were developed to quantify biological diversity. - Such measures are also used as diversity metrics to quantify heterogeneity of organisms - Such measures are also used to quantify the amount of heterogeneity within organizations (gender, race etc.), dispersion of some attributes within organizations (experience, skill) or attitudes,	- Sector level analysis - Two heterogeneity indices were calculated based on the dispersion of various innovative groups within industries and the relative position of firms with respect to each other based on their innovative attitudes	- Simpson index based on dispersion of innovative groups within sectors - Average Euclidean distance of all possible firm pairs based on factor scores obtained in (2)	- Heterogeneity indices:

Table 8 (continued)

(5) Determinants of intra-industry heterogeneity	- Selection reduces heterogeneity, while variety generation mechanisms increase it. - According to Schumpeter's Mark I Model, innovation is mainly driven by entrepreneurs and small firms that introduce break-through technologies - Schumpeter's Mark II Model is characterized by gradual innovations and dominance of large incumbent firms	- Variables pertaining to selection (i.e. variables that are expected to reduce heterogeneity) and variety (i.e. those that are expected to increase heterogeneity) were used to verify their relationship with the observed heterogeneity within sectors	- Regression tree analysis: Output attributes are heterogeneity indices obtained in (4). - Time series regression analysis: Dependent variables are heterogeneity indices obtained in (4). Fixed-effects panel regression models are estimated.	-Decision trees - Regression analysis results - Sector level determinants of intra – industry heterogeneity

Table 8 (continued)

(6) Effects of intra-industry heterogeneity on innovation process	- Innovation process can be abstracted into different stages for modelling purposes - Diversity may have a positive impact on productivity (Jacobs externalities)	- Innovation decision, innovation investment, knowledge production and overall production functions can be estimated - Heterogeneity indices calculated in (4) can be used as explanatory variables	- CDM variant used in the OECD Microdata Project was adopted	- CDM estimation results

CHAPTER 4

FIRM LEVEL CLASSIFICATION AND PATTERNS OF INNOVATION

Classification of firms according to their innovative attributes is the fundamental building block of this thesis. As outlined in the previous chapters, innovative activities of firms are assumed to be analogous to genes from an evolutionary perspective. Therefore, classificatory analysis is expected to deliver a phenotypic taxonomy of innovative firms, from which the presence of diverse innovative behavior within a sector can be further analyzed.

Metrics based on the proportion of different groups provide insight about one aspect of heterogeneity, i.e. variety, within a sector. Another metric based on the relative innovative position of firms is also used in order to add robustness to the analysis. Frenz and Lambert (2010) report implementation of factor analysis method to determine innovation patterns for a number OECD countries. A similar approach was also adopted in this thesis to identify innovation patterns in Turkey. Moreover, obtained factor scores were used to calculate a heterogeneity metric based on the relative position of firms within a sector according to their innovation activities.

Classification steps followed in this thesis are summarized in the following section. Latent class analysis results and interpretation of obtained groups are also given in this part.

Subsequent section is devoted to the analysis of innovation patterns in Turkey. Adoption of the methodology used in the OECD Microdata project is briefly discussed; followed by the presentation of analysis results and comparison of obtained findings with other OECD countries. Final section in this chapter summarizes analysis results and associates obtained research findings with micro and macro level analysis on sources of intra – industry heterogeneity, which is presented in Chapter 5.

4.1 Classification of Firms with Respect to Their Innovative Aspects

4.1.1 Methodological Approach

Hair et al. (1998) and Milligan (1996) propose similar strategies for research problems that involve classification of entities. Cluster analysis based approaches proposed by these authors are outlined in Table 9.

Table 9 Classification strategies

Step	Approach 1 (Hair et al., 1998)	Approach 2 (Milligan, 1996)
1	Setting the research problem; defining objectives; select clustering variables	Select clustering elements: Choose the entities that are going to be classified
2	Treatment of outliers	Select clustering variables
3	Clarification of assumptions	Variable standardization
4	Select clustering algorithm / classification method	Select measure of similarity
5	Interpretation of clusters	Select clustering algorithm / classification method
6	Validate and profile clusters	Identify number of clusters (either by stopping rules or according to a priori assumptions)
7	-	Interpretation of results

These approaches were synthesized and firms were classified following the steps explained below:

Step 1 – Selection of entities to be classified: This thesis aims to measure the amount of heterogeneity related to different innovation profiles of firms. Therefore, the unit of analysis is the firm. As can be seen in Table 7, most of the questions are directed towards innovative firms (i.e. non – innovative firms have missing values for these questions); hence only "innovative" firms could be analyzed.

Step 2 – Selection of variables: As outlined in the previous chapter, innovation surveys provide a number of binary and ordinal variables, which depict the innovative aspects of firms. Previous studies (Leiponen & Drejer, What exactly are technological regimes? Intra-Industry heterogeneity in the organisation of innovation activities, 2007; Srholec & Verspagen, 2008) make use of variables pertaining to product and process innovations, sources of knowledge, cooperation preferences and impact of innovations to categorize firms. More recently OECD's Innovation Microdata Project provides modes of innovation for firms of a number of countries based on factor analysis of some binary variables (Frenz & Lambert, 2010). Calculated factor scores are then used in the k-means cluster analysis. Framework put forward in OECD Innovation Microdata Project is adopted in this thesis, in order to allow for comparability of findings. Binary variables used in the classificatory scheme are outlined in Table 10.

Table 10 Variables used in classification of firms

Variable name	Variable description
prodin_nm	Product innovation new to market
prodin_nf	Product innovation new to firm
procin	Process innovation related to new manufacturing methods, logistics and maintenance techniques

Table 10 (continued)

rdin	Expenditure on intramural research and development
rdout	Expenditure on extramural research and development
inmach	Expenditure on machinery, software etc.
inipr	Expenditure on acquisition of external knowledge
inedu	Expenditure on education
inmar	Expenditure on marketing of innovations
org1	New knowledge management system
org2	Change to the organization of work
org3	Change in relationships with other firms
mar1	Changes in design or packaging
mar2	Changes in sales or distribution methods
coop	Engagement in some form of cooperation

Variables related to intellectual property protection actions of firms are used in the OECD Micro Data Project. As can be seen in Table 7, these variables are not present in IS2008; hence they could not be utilized in the analysis.

Step 3 – Selection of clustering method: Previous studies, which analyze innovation survey data to classify firms, use polychoric or tetrachoric correlation matrices for factor analysis; then calculated factor scores are fed to the subsequent k-means cluster analysis. Binary, ordinal and categorical variables cannot be directly used in k-means cluster analysis since it is not possible to estimate the cluster centers correctly. On the other hand, latent class analysis can handle binary data. Therefore, latent class analysis was used to group firms according to the variables listed in Table 10. poLCA, a latent class analysis tool developed by Linzer and Lewis (2011) for R! statistical package, was used for this purpose.

Step 4 – Identification of number of classes: Latent class analysis allows determination of appropriate number of classes using parsimony measures such as Akaike Information Criterion or Bayesian Information Criterion. Moreover Pearson's χ^2 goodness of fit and likelihood ratio chi-square (G^2) can also be used for this purpose. poLCA provides all these metrics after the estimation of class membership probabilities. Latent class analysis in this thesis started with 2 classes. Analysis was ceased when the number of classes iteratively reached 10. Number of classes to retain was determined according to the aforementioned goodness of fit metrics.

Step 5 – Interpretation of results: Latent class analysis provides probability of a response conditional on belonging to a given class (e.g. probability of introducing a product innovation new to the market conditional on belonging to a given class). These response probabilities, in addition to other variables such as average number of employees, share of sales due to new or improved products, and expenditure on innovation are used to characterize obtained classes.

Variables listed in Table 10 are closely related to a firm's methods of doing business; therefore it can be argued that these variables may proxy routines or habits of a firm. Following Nelson and Winter (1982) these variables are analogous to genes in a living organism. On the other hand, if phenotype of an organism is characterized by its genotype in addition to environmental factors, then innovation groups (obtained by latent class analysis) represent the phenotypic expression of firms within a sector. Note that this 'analogy' is used to align he theoretical framework of this thesis to that of Nelson and Winter (1982).

4.1.2 Latent Class Analysis Results

Latent class models with 2 to 10 groups were estimated in order to determine the optimum number of groups to retain. Related goodness of fit indicators are presented in Table 11.

Table 11 Goodness of fit indicators for latent class analysis

# Class	AIC	BIC	χ^2	G^2
2	69858.52	70066.54	86020.19	11911.65
3	68425.76	68740.94	56070.73	10524.89
4	67442.25	67864.60	41323.06	9507.38
5	67040.77	67570.28	38130.35	9071.89
6	66765.62	67402.30	**37021.17**	**8762.75**
7	66502.14	67245.99	38487.11	8965.27
8	66241.07	67092.08	39265.51	9170.20
9	66059.37	67017.54	40339.32	9465.27
10	65918.90	66984.24	40630.61	9780.03

Lower AIC and BIC values were obtained with increased number of groups. On the other hand, minimum values of χ^2 (Pearson's chi-square) and G^2 (likelihood ratio chi-square) were obtained with the 6 group solution. Therefore, results pertaining to the 6 group latent class model were used in the subsequent analyses.

Results of the 6 group latent class analysis are shown in Table 12. Given group membership, the conditional probabilities shown in each cell specify the likelihood such that related variable has a value of 1 (since all the variables used in the model are binary). For example, a firm in Group 1 has a 98.9% probability of conducting in house research and development, whereas this value is as low as 12.5% for a firm in Group 6. Descriptive statistics of these groups are given in Table 13.

Table 12 Identified innovation groups

	Group1	Group2	Group3	Group4	Group5	Group6
Product innovation new to market	0.7519	0.5193	0.5578	0.5547	0.305	0.3928
Product innovation new to firm	0.3207	0.424	0.3563	0.5073	0.331	0.42
Process innovation	0.9238	0.7511	0.7375	0.8592	0.8953	0.5531
Expenditure on intramural research and development	0.989	0.2316	0.6871	0.6485	0.588	0.1252
Expenditure on extramural research and development	0.7118	0.0438	0.2485	0.1381	0.2287	0.0077
Expenditure on machinery, software etc.	0.973	0.1268	0.7829	0.7107	0.8103	0.325
Expenditure on acquisition of external knowledge	0.5742	0.021	0.279	0.2859	0.1972	0.0153
Expenditure on education	0.9682	0.047	0.7796	0.8479	0.8866	0.1451
Expenditure on marketing of innovations	0.8925	0.0672	0.6965	0.8441	0.3857	0.1248
New knowledge management system	0.8906	0.8009	0.1088	0.8985	0.8354	0.0395
Change to the organization of work	0.8792	0.7962	0.0731	0.8825	0.8243	0.065
Change in relationships with other firms	0.4252	0.2974	0.01	0.3105	0.2508	0.0144
Changes in design or packaging	0.6449	0.4372	0.2628	0.7986	0.0535	0.0931
Changes in sales or distribution methods	0.4636	0.3501	0.1747	0.7111	0.0581	0.0472
Engagement in some form of cooperation	0.6218	0.2133	0.2293	0.3483	0.3393	0.0848
Legend	High					Low

Table 13 Summary statistics for different innovation groups

	Group1	Group2	Group3	Group4	Group5	Group6
2004						
# of obs.	301	74	219	165	207	128
10-24 employees	11%	20%	21%	17%	10%	28%
25-49 employees	16%	26%	22%	22%	19%	30%
50-249 employees	27%	39%	37%	38%	39%	27%
+250 employees	46%	15%	19%	24%	32%	13%
% new to market product	16.21%	7.89%	15.18%	13.97%	5.02%	7.41%
% new to firm product	11.40%	10.89%	9.11%	10.43%	4.01%	47.24%
Average Innovation expenditure intensity	2.29%	0.42%	2.18%	2.08%	1.98%	0.69%
2006						
# of obs.	61	115	84	131	90	138
10-24 employees	10%	26%	21%	18%	16%	36%
25-49 employees	11%	20%	19%	16%	22%	23%
50-249 employees	11%	14%	32%	19%	28%	25%
+250 employees	67%	39%	27%	47%	33%	17%
% new to market product	20.93%	12.12%	27.23%	24.90%	11.62%	10.93%
% new to firm product	15.98%	14.40%	12.21%	16.24%	8.57%	36.94%
Average Innovation expenditure intensity	4.97%	0.29%	4.51%	1.81%	2.68%	1.33%
2008						
# of obs.	180	113	564	175	187	448
10-24 employees	6%	25%	22%	22%	15%	35%
25-49 employees	12%	12%	17%	15%	13%	16%
50-249 employees	30%	32%	34%	30%	33%	31%
+250 employees	53%	31%	26%	33%	39%	17%
% new to market product	22.01%	11.63%	24.99%	21.52%	13.26%	11.09%
% new to firm product	22.46%	14.85%	16.19%	18.77%	12.91%	33.15%
Average Innovation expenditure intensity	2.97%	%0.69	2.89%	2.80%	2.68%	1.44%

Assuming *routines* (i.e. rules and heuristics related to ways of doing business) are analogous to *genes,* then Table 12 represents the phylogenetic taxonomy of innovative firms. Consequently, average numbers reported in Table 13 pertain to the *phenotypic* characteristics of firms that are allocated to each group.

4.1.3 Interpretation of Classes

In biology, taxonomy refers to identification, classification and nomenclature of organism. Latent class analysis provided the likelihood of conducting certain innovation related activities, such as performing in-house research and development or cooperation with other parties, conditional on belonging to a group. These probabilities, together with descriptive statistics of retained classes are used to interpret the emerging characteristics of identified innovation groups. This task is analogous to naming of organisms in taxonomic studies. Accordingly, a name that has a taxonomic meaning and providing information about the phylogenetic relationships is assigned to each group.

High – Profile Innovators (HPI – Group 1): Large firms (i.e. firms that have more than 250 employees) constitute the majority in this group. Highest innovation expenditure intensity is observed in this group as well. Firms in this category have the highest likelihood of introducing new-to-market product innovations as well as process innovations. Highest tendency to invest in innovation related machinery and equipment and acquisition of external knowledge, in addition to activities related to training of personnel and marketing is observed in this group. Moreover HPI firms have the highest propensity to cooperate with other parties in their innovative activities. It can be argued that HPI firms, characterized by their large size and high investment capacity, are typical examples of innovative firms in Schumpeter's Mark II model.

Low – Profile Efficiency Seekers (LPES – Group 2): Firms in this group are characterized by the low level of innovation related investments. Small and medium sized firms constitute the majority in this group. LPES firms have a high tendency to introduce process innovations as well as organizational innovations such as introduction of new knowledge management systems or re-organization of the firm structure. Therefore, it can be argued that firms in this group seek to gain competitive advantage by improving their process and organizational efficiency, with minor changes and adjustments that do not require rigorous investments.

Technology Oriented Innovators (TOI – Group 3): Middle sized firms (i.e. firms that have more than 50 but less than 250 employees) dominate this category. Firms in this group have the second highest likelihood of conducting in-house research and development and innovation expenditure intensity. On the other hand, their proclivity to introduce organizational and marketing innovations is rather low. Moreover firms in this group exhibit a lower tendency to cooperate with other parties.

Market Oriented Innovators (MOI – Group 4): Firms in this group can be characterized by their high inclination towards undertaking organizational and marketing innovations. Highest probability of introducing marketing innovations such as changing the design or packaging of products or implementation of new sales channels are encountered in this group. MOI firms have the second highest propensity to cooperate with other parties; therefore, it can be argued that firms in this group benefit from the information provided by their clients.

Process Oriented Innovators (POI – Group 5): Firms in this group have the lowest share of sales from new products. POI firms have the second highest propensity to introduce process innovations. POI firms also have a high tendency for acquisition of advanced machinery, equipment and computer hardware or software to produce new or significantly improved products and processes. This group is mainly populated by small and medium sized firms; however large firms also have a strong presence in this group. In all three periods, large firms constitute one third of all POI firms. Firms in this group have an above average tendency for cooperation; hence it can be assumed that POI firms collaborate with their suppliers in their innovation activities.

Low – Profile Product Innovators (LPPI – Group 6): Small firms (i.e. firms that have less than 50 employees) are most commonly encountered in this group. Firms in this group have the lowest tendency to undertake any innovation related activity. Moreover they have the second lowest innovation expenditure intensity. As can be seen in Table 13, LPPI firms have the highest ratio of sales stemming from new-to-firm product innovations. Consequently, it can be argued that this group is populated with small imitating firms, which adopt existing products to their established processes.

4.2 Exploring Patterns of Innovation with Factor Analysis

4.2.1 Methodological Approach

Recent studies (Leiponen & Drejer, 2007; Srholec & Verspagen, 2008; Frenz & Lambert, 2010; Yurtseven & Tandoğan, 2012) empirically show that there are latent patterns of innovation, which are not industry specific and industries are populated with sub-groups of firms with different innovative characteristics. Frenz and Lambert's (2010) study is of particular interest since it comparatively analyzes innovation patterns observed in 9 different OECD countries. Existence of such latent patterns of innovation was also explored in this thesis for two main purposes. First, obtained factor scores were utilized to construct a heterogeneity index based on the average Euclidean distance between firms within the same industry. Second, identified patterns of innovation were compared to those obtained in the OECD Microdata Project.

Principal component factors method was used for factor extraction, since it does not depend on any distributional assumptions. Rotation of extracted factors is necessary for interpretation. Factor analysis should be run on continuous variables, or ordinal variables with broad ranges to allow for identifying reasonable covariance matrices (Hair et. al., 1998). Therefore, polychoric correlation matrices, as suggested by Kolenikov and Angeles (2004), were used in the factor analysis with the assumption that binary variables listed in Table 10 reflect underlying latent continuous variables.

Factor scores were calculated using the Bartlett's method by multiplying the row vector of observed variables, by the inverse of the diagonal matrix of variances of the unique factor scores, and the factor pattern matrix of loadings. In the next step obtained values were multiplied by the inverse of the matrix product of the matrices of factor loadings and the inverse of the diagonal matrix of variances of the unique factor scores. Obtained factor scores were then used to calculate the heterogeneity index based on dissimilarity of innovation modes.

4.2.2 Modes of Innovation in Turkey – Factor Analysis Results

Factor analysis results are presented in Table 14. Four factors with eigen values greater than 1 explain 67.08% of the variance in the data set. Independent factors are obtained (i.e. factors are not correlated) by varimax rotation.

Table 14 Factor analysis results

	Factor1	Factor2	Factor3	Factor4
Product innovation new to market	0.5642	-0.0337	0.7312	0.0821
Product innovation new to firm	0.1656	-0.0234	0.5291	0.7844
Process innovation	0.3683	0.5368	-0.327	0.5412
Expenditure on intramural research and development	0.7399	0.1432	0.2266	0.1695
Expenditure on extramural research and development	0.735	0.1946	0.0663	0.0962
Expenditure on machinery, software etc.	0.6441	0.8884	0.0836	-0.0425
Expenditure on acquisition of external knowledge	0.6928	0.1352	0.1398	-0.0007
Expenditure on education	0.7895	0.2525	0.1095	0.0284
Expenditure on marketing of innovations	0.6354	0.0779	0.5335	0.0066
New knowledge management system	0.1824	0.8625	0.1828	0.0225
Change to the organization of work	0.1481	0.8671	0.1802	-0.0061
Change in relationships with other firms	0.072	0.7969	0.1319	0.0143
Changes in design or packaging	0.1564	0.3868	0.7133	-0.0427
Changes in sales or distribution methods	0.1025	0.4394	0.6619	-0.1064
Engagement in some form of cooperation	0.4072	0.4626	0.0391	-0.0056
legend	High			Low
Eigen value	5.371	1.965	1.419	1.306
% variance explained	35.81	13.10	9.46	8.71
Cumulative	35.81	48.91	58.37	67.08

Based on the loading values, factor 1 is interpreted as “technology oriented product innovation” mode. Variables pertaining to different classes of innovation expenditure in addition to new-to-market innovation have a high bearing on this factor.

Factor 2 is labeled as “efficiency oriented innovation” mode since process and organizational innovation variables, of which ultimate goal is to increase the efficiency of business operations, are highly correlated to this factor. Moreover acquisition of machinery and equipment has the highest loading on this factor.

Factor 3 is designated as “market oriented product innovation”. Variables related to marketing innovation have relatively high loadings on this factor. Moreover, this factor is highly correlated with product innovation variables.

Last factor is labelled as “imitation based innovation” since new-to-firm product innovation together with process innovation have high loadings. None of the variables related to other innovation activities are closely correlated to this factor.

This thesis has a common foundation with the OECD Innovation Microdata Project, since harmonized innovation surveys were used in both studies. Instead of classifying firms with k-means cluster analysis based on normalized scores obtained from factor analysis, latent class analysis was used in this thesis. Same binary variables were used in the latent class models and the factor analyses that were performed within the scope of the OECD Innovation Microdata Project. Factor analysis was performed to allow for a more in-depth comparison with the OECD Microdata Project and to construct a heterogeneity index based on the dissimilarity of innovation modes.

4.2.3 Comparison with the OECD Innovation Microdata Project

Frenz and Lambert (2010) report common innovation patterns derived from the factor analyses, which were undertaken for nine countries that had participated in the OECD Innovation Microdata Project. Common modes of innovation identified in these nine countries are listed below:

- New-to-market innovating
- Marketing based imitating
- Process modernizing
- Wider innovating

According to Frenz and Lambert (2010), new-to-market innovating mode, which depends on firm's own technology generation capabilities, is prevalent in all countries. Their findings indicate that externally acquired research and development is positively correlated with in-house R&D in Austria, Denmark and New Zealand. Moreover, IPR protection has a higher bearing on new-to-market innovating mode in Canada, France, New Zealand and the United Kingdom; whereas firms in New Zealand follow a more open strategy in this mode.

New-to-firm product innovations and expenditure on marketing activities are closely related to marketing – based imitating mode, which emerges in Austria, Brazil and New Zealand. On the other hand, this mode is not observed in Korea and Norway (Frenz & Lambert, 2010).

In Austria, Brazil, Canada, Denmark and the United Kingdom embedded technology transfer in the mode of acquisition of advanced machinery and software plays an important role on the process modernizing innovation mode. In-house and extramural research and development complements these process enhancing activities in Korea (Frenz & Lambert, 2010).

Wider innovating mode refers to organizational and marketing innovations. Frenz and Lambert (2010) report the occurrence of this mode in all countries, for which the relevant information was available.

New-to-market innovating mode refers to the “technology oriented product innovation” mode in Turkey, since both patterns are highly correlated with in-house innovation activities. In some countries such as Denmark, New Zealand, Norway and the United Kingdom product innovation variables have relatively lower loadings on new-to-market innovating mode. In this sense, “technology oriented product innovation” mode in Turkey resembles to the “technology innovating and process modernizing” mode in France.

Process modernizing mode is closely related to the “efficiency oriented innovation” mode in Turkey with some exceptions. Process modernizing mode in Norway is not complemented with machinery acquisition, i.e. it mainly depends on process and organizational innovations. In other countries process innovation and organizational innovation activities appear in different factors.

Marketing based imitating mode resembles to “market based innovation” mode in Turkey to some extent, since new-to-firm innovation is dominant in the former mode whereas new-to-market product innovation dominates the latter pattern in Turkey. On the other hand, “imitation based innovation” mode in Turkey lacks the marketing elements found in the Marketing based imitating mode.

Although different methodologies were used, it is still possible to compare the results obtained from the latent class analysis with the findings of the OECD Innovation Microdata Project.

New-to-market innovating mode, which is closely related to introduction of new-to-market products and expenditure on in-house research and development, is prevalent in High Profile Innovators (HPI) and Technology Oriented Innovators

(TOI) groups identified in this study. Moreover it can be argued that marketing based imitating mode is dominant in the Low-Profile Product Innovators group; since firms in this group have the highest percentage of sales related to new-to-firm product innovations.

Low-Profile Efficiency Seekers and Process Oriented Innovators can be characterized by the process modernizing innovation mode; whereas non-technical innovations are more commonly encountered in the Market Oriented Innovators group, which can be characterized by the wider innovation mode.

4.3 Concluding Remarks

Empirical analyses presented in this Chapter were conducted to produce two main outcomes. First, “phylogenetic classification” of innovative firms in Turkey was put forward using the theoretical framework outlined in Chapter 2. Latent class analysis results indicate that there are six different groups of innovative firms with distinct characteristics. Second, four patterns of innovation, which are comparable to innovation forms in other OECD countries were identified.

Sectoral innovation systems approach suggests that firms nested in a sector may display similar innovation patterns since they share a common knowledge base and their perceived incentives for innovation are alike. On the other hand, existence of such distinct firm classes and innovation patterns hints that sectors are heterogeneous in terms of innovative behavior. Such heterogeneity may have firm and sector level determinants according to the theoretical framework adopted in this thesis. Therefore, next chapter is dedicated to the analysis of firm and sector determinants of intra – industry heterogeneity. Firm’s class information and heterogeneity metrics that are based on the dispersion of various firm groups within sectors and relative innovative position of firms are used for this purpose.

CHAPTER 5

DETERMINANTS OF INTRA – INDUSTRY HETEROGENEITY

Theoretical framework of this thesis is based on evolutionary economics and resource based theory of the firm, which provides two different but interrelated strands of research. Firm level determinants of diverse innovative behavior is analyzed from a resource – based perspective, whereas macro level analysis is based on the Neo – Schumpeterian theme of evolutionary economics advocated by Nelson and Winter (1982).

Firms within the same line of business may opt for different innovation strategies depending on their resources (Barney, 1986; Dierickx and Cool, 1989; Peteraf, 1993), knowledge base (Nonaka, 1994; Spender and Grant, 1996; Grant, 1996) and their network position (Hamel, 1991; Dyer and Singh, Gulati et al., 2000). Firm strategy can emerge as activity patterns; hence firm clusters identified in the previous chapter may indicate distinct innovation strategies. Therefore, a predictive model should provide insight about the relationship between firm's strategic alignment and its resource base. Firm level determinants of diversity in innovation strategies were analyzed with recursive partitioning methods for this purpose. Following section outlines the methodological approach and classification tree analysis results.

Quantification of intra – industry is essential in analyzing the sources and determinants of distinct innovation patterns observed within sectors. Metrics that were used to quantify intra – industry heterogeneity of innovative behavior are introduced in Section 5.2 Macro level analysis of such heterogeneity with regression tree and fixed effects panel models is presented in Section 5.3. This chapter is concluded with an overview of obtained findings from an evolutionary perspective.

5.1 Firm Level Determinants of Intra – Industry Heterogeneity

5.1.1 Methodological Approach

A classification tree was constructed to predict the class membership of firms based on their resource base (i.e. number of employees, innovation expenditure per employee, innovation expenditure intensity), knowledge base (sources of knowledge, number of knowledge sources) and cooperation status (type and number of cooperation). Firm's activity in export markets and its ownership status (i.e. being part of a group or equity partnership with a foreign firm) may have a bearing on firm's network position as well as its knowledge base. Therefore, these variables are also added to the model. Variables used in the model are summarized in Table 15.

Table 15 Variables used in the prediction of class membership

Variable Name	Variable Description	Category
empave	Number of employees (continuous)	Resource base
inexppc	Innovation expenditure per employee (continuous)	Resource base
inexpint	Innovation expenditure intensity (continuous)	Resource base
coop1	Firm has cooperated with clients (binary)	Network
coop2	Firm has cooperated with suppliers (binary)	Network
coop3	Firm has cooperated with private research entities (binary)	Network

Table 15 (continued)

coop4	Firm has cooperated with public research entities (binary)	Network
coopno	Total number of cooperations (0-4)	Network
knowsource1	Sum of importance attached to knowledge from other group companies, suppliers, clients, competitors (0-12)	Knowledge base
knowsource2	Sum of importance attached to knowledge from universities, public and private research organizations (0-9)	Knowledge base
knowsource3	Sum of importance attached to tradeshows, journals and NGO's (0-9)	Knowledge base
knowsourceno	Number of knowledge sources (0-10)	Knowledge base
expo	Firm's activity in foreign markets (binary)	Network Knowledge base
group	Firm's affiliation with a group (binary)	Network Knowledge base
foreign	Firm's ownership status (binary)	Network Knowledge base

rpart, a recursive partitioning tool developed by Therneau and Atkinson (1997) for R! statistical package, was used for the classification tree analysis.

As outlined in the previous chapter, High Profile Innovators (HPI) group is characterized by their large size and they pursue a variety of innovative activities simultaneously. Moreover HPI firms have a high propensity for collaboration with other entities. Therefore, classification tree model is expected to allocate large firms (in terms of number of employees) with that have high innovation expenditure intensity to the HPI category.

Low Profile Product Innovators (LPPI), on the other hand, emerge as the exact opposite category of HPI. This category is populated with small firms with low innovation expenditure intensity. Moreover firms in this group have the least tendency towards collaboration with other organizations. Therefore, small firms, with low innovation expenditure are expected to be assigned to this category. Firms in the Low – Profile Efficiency Seekers (LPES) group have similar characteristics to the LPPI category, except their higher tendency towards process innovations. Consequently, firms that have enablers for process innovation (i.e. cooperation with suppliers and clients) but do not intensely invest in innovation may be assigned to the LPES category.

Technology Oriented Innovators (TOI) group largely consists of middle sized firms with a relatively high level of innovation expenditure intensity and TOI firms have the second highest propensity for conducting in – house R&D. TOI and HPI firms are expected to appear on the same branches of the classification tree; however TOI firms should be diverted to branches with lower values of number of employees and innovation intensity at nodes pertaining to these variables.

Market Oriented Innovators (MOI) group is characterized by their high inclination towards organizational and marketing innovations. Moreover MOI firms have above average tendency for cooperating with other parties. Consequently, firms that benefit from the knowledge pool of clients and cooperate with them are expected to be allocated to this group.

As the name implies, Process Oriented Innovators (POI) firms are prone to introduce process innovations and invest in machinery and other equipment. Therefore, firms that cooperate with their suppliers and use them as a knowledge source in their innovative activities are expected to be allocated to this group.

Results of the predictive analysis based on classification tree method are presented in the following sub – section.

5.1.2 Class Membership Prediction

Classification tree analysis results are presented in Figure 13. Prediction performance of the model is summarized in Table 16. Overall accuracy of the model, i.e. the ratio of correctly classified observations over all observations, is about 69.61%. Sensitivity, specificity and accuracy for each group prediction are presented in Table 17.

Table 16 Predicted vs observed values

Predicted Value	Observed Value						
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Total
Group 1	391	41	62	40	24	9	567
Group 2	38	181	32	15	34	26	326
Group 3	32	17	571	51	45	32	748
Group 4	25	19	61	321	51	27	504
Group 5	32	21	74	33	298	29	487
Group 6	24	23	67	11	32	591	748
Total	542	302	867	471	484	714	

Table 17 Prediction power indicators

Group Name	Sensitivity[9]	Specificity[10]	Accuracy[11]
Group 1	72.14%	93.80%	68.96%
Group 2	59.93%	95.29%	55.52%
Group 3	65.86%	92.96%	76.34%
Group 4	68.15%	93.71%	63.69%
Group 5	61.57%	93.47%	61.19%
Group 6	82.77%	94.11%	79.01%

Highest model accuracy was attained for predictions made for Group 6; whereas poorest prediction performance was for Group 2. Classification tree model

[9] Sensitivity is number of true positives divided by the sum of number of true positives and false negatives. Sensitivity is related to model's ability to identify a case correctly.

[10] Specificity is number of true negatives divided by the sum of number of true negatives and false positives. Specificity is related to model's ability to exclude false cases correctly.

[11] Accuracy is the sum of true positives and true negatives divided by the total number of observations. Accuracy is related to the overall predictive power of the model.

shown in Figure 13 can predict the group memberships for High Profile Innovators, Technology Oriented Innovators and Low Profile Product Innovators with an approximately 70% accuracy. Recursive partitioning algorithm implemented in the rpart package tries to find the single variable that “best” splits the data into two and ranks each variable included in the model accordingly. Therefore, some variables may be omitted from the constructed classification tree. In this case 9 of the 15 variables described in Table 15 were used in constructing the classification tree.

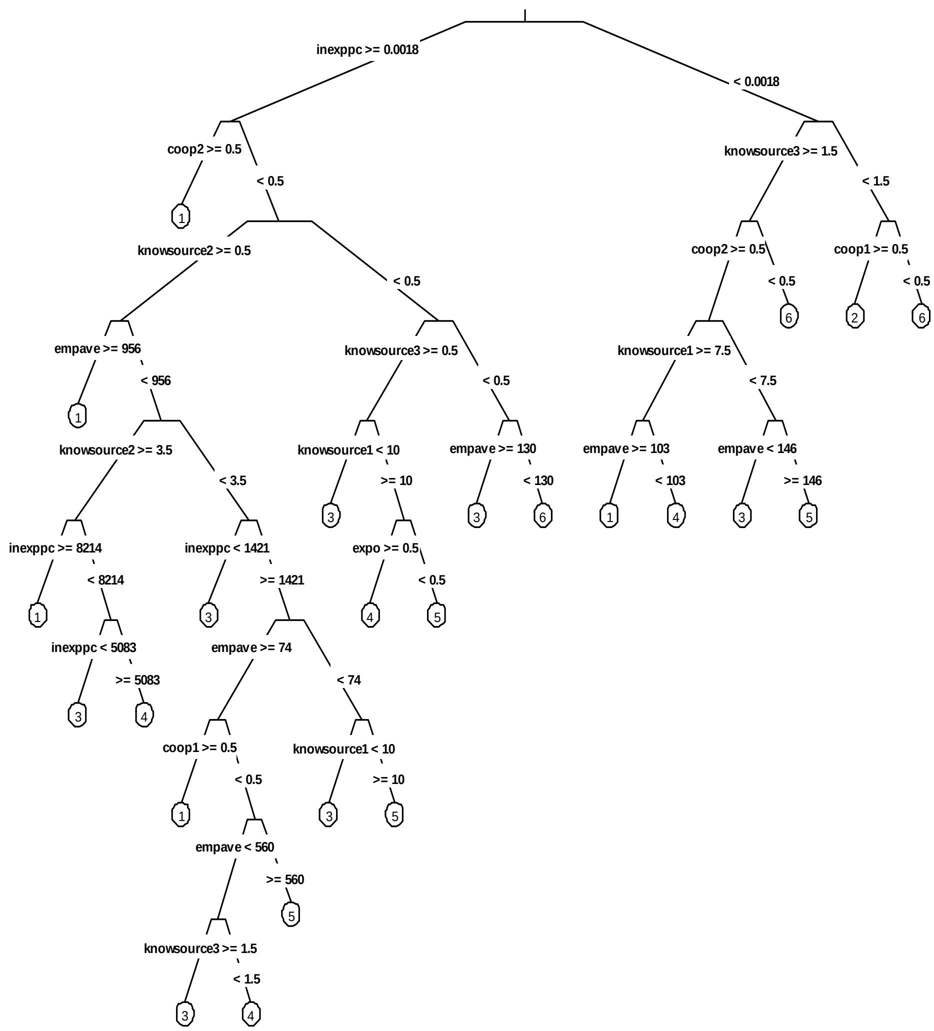


Figure 13 Classification tree for predicting the innovation group membership

As can be seen in Figure 13 each node has a binary partition argument. TRUE logical values are assigned to left branches. Partitioning in the classification tree shown in Figure 13 starts with splitting observations into two groups based on their innovation expenditure per employee values. Observations that have some (i.e. greater than zero) innovation expenditure are assigned to the uppermost left branch of the tree.

High Profile Innovators (HPI – Group 1) are allocated to the left branches; whereas Low Profile Product Innovators (LPPI – Group 6) frequently appear on the right branches of the classification tree.

Following classification rule can be proposed for Low Profile Efficiency Seeker:

Group 2 – Rule 1: (i) If the firm's innovation expenditure per employee is smaller than 0.0018 (i.e. practically 0) and (ii) if its knowledge source from trade shows, journals etc. is smaller than 1.5 (over 9) and (iii) if it cooperates with clients (i.e. coop1 = 1) then it should belong to Group 2.

Similar classification rules can be derived for other innovation groups as well:

Group 3 – Rule 1: (i) If inexppc<0.018 and (ii) knowsource3>=1.5 and (iii) coop2 = 1 and (iv) knowsource1<7.5 and (v) empave<146 then firm should belong to Group 3.

Group 4 – Rule 1: (i) If inexppc<0.018 and (ii) knowsource3>=1.5 and (iii) coop2 = 1 and (iv) knowsource1>=7.5 and (v) empave<103 then firm should belong to Group 4.

Group 5 – Rule 1: (i) If inexppc<0.018 and (ii) knowsource3>=1.5 and (iii) coop2 = 1 and (iv) knowsource1<7.5 and (v) empave>=146 then firm should belong to Group 5.

Recursive partitioning algorithm allocates large firms with high innovation expenditure intensity to the High Profile Innovators group. This result is in line with the expectations outlined in the previous sub – section. When leaves of the classification tree in Figure 13 are examined, it can be seen that firms that are assigned to the HPI group also benefit from a broad knowledge base and cooperate with their clients and suppliers.

On the other hand, smaller firms that have low levels of innovation expenditure are allocated to either Low Profile Efficiency Seekers (LPES) or Low Profile Product Innovators (LPPI) groups. As can be seen in Table 17, applied model was relatively more successful in identifying LPPI firms than LPES firms. It can be argued that HPI group and LPPI (in addition to LPES) firms form a dichotomy, which is similar to Schumpeter's Mark II model. In this setting, innovative activities are mainly driven by large firms, which have the necessary resources to invest in research and development. Moreover firms in the HPI group are characterized by their dependence on a broad knowledge base and networking capabilities. However, overall picture is far from a dichotomous structure.

Technology Oriented Innovators (TOI) have resembling properties to HPI. As can be seen in Figure 13, TOI and HPI firms appear on the same branches of the classification tree; however smaller firms that have lower innovation expenditure (when compared with HPI firms) are diverted to the TOI category at terminal nodes. This finding also conforms to the initial expectations outlined in the previous sub – section.

Smaller firms that use knowledge from suppliers and clients and cooperate with them are generally assigned to the Market Oriented Innovators (MOI) group. As can be seen in Figure 13, Process Oriented Innovators (POI) may appear on the same branches with MOI firms; however smaller firms are assigned to the MOI group at the terminal nodes.

Classification tree analysis results indicate that resource endowment, type and breadth of knowledge base in addition to networking capabilities of a firm have a bearing on its innovation strategy. Obtained findings support the theoretical framework of this thesis, which suggests resource, knowledge and relational bases of a firm constitute the firm level determinants of intra – industry heterogeneity. Following sections are devoted to the analysis of intra – industry heterogeneity at the sectoral level.

5.2 Quantification of Intra – Industry Heterogeneity

5.2.1 Methodological Approach

poLCA, which is the software module used for latent class analysis outlined in the previous chapter, estimates the posterior class membership probability for each entity; then each entity is assigned to the class with the maximum belonging probability. After each firm is assigned to a class, sectoral (2-digit NACE Rev 1.1 sectors) dispersion of different innovation groups is calculated according to the adjusted Simpson Index[12]. 122 observations in 3 periods were obtained, after collapsing the data to the sector level. In order to obtain consistent results, Simpson Index was calculated for sectors containing more than 10 innovative firms. Therefore, 32 observations were discarded from the sector level data set. Discarded sectors are listed in Table 18.

Table 18 Discarded sectors

Reference Year	Discarded 2-digit Sectors (NACE Rev 1.1)
2004	11, 12, 13, 16, 30, 37, 61,
2006	10, 11, 13, 16, 19, 20, 21, 23, 30, 32, 33, 35, 37, 61, 62
2008	11, 13, 16, 20, 23, 30, 32, 37, 61, 62

[12] See Equation 18 in section 3.3.

Woerter (2009) uses a diversity measure, which is the average Euclidean distance[13] of all possible firm pairs nested in an industry based on their resource base (i.e. R&D intensity, education level, firm size and export behavior). A similar heterogeneity index was calculated using the factor scores outlined in section 4.2.

5.2.2 Calculated Heterogeneity Indices

Calculated adjusted Simpson index (HET6) and average Euclidean distance (HETEUC) are presented in Table 19. Fluctuations in heterogeneity metrics for the same sector may be due to variations in sample sizes. Relation between HET6 and HETEUC is presented in Figure 14. As can be seen in Figure 14, there is a positive correlation between these two metrics.

Figure 15 shows that HET6 decreases as average number of employees in that sector increases. This preliminary finding conforms to the proposition put forward in the theoretical framework, which suggests that observed heterogeneity within a sector should diminish with increasing severity of selection. However a strong correlation between HETEUC and average firm size was not observed as shown in Figure 16.

Table 19 Calculated heterogeneity indices

NACE Rev.1.1 Sector	HET6			HETEUC		
	Year					
	2004	2006	2008	2004	2006	2008
10	3.37	n.a.	2.10	38.02	n.a.	37.08
14	4.75	3.14	3.07	45.24	52.76	126.26
15	4.24	3.94	2.87	173.74	109.78	226.75
17	4.87	2.97	3.29	127.27	112.18	242.75
18	2.84	4.37	1.81	69.16	78.44	117.64
19	2.87	n.a.	2.53	34.98	n.a.	19.49
20	4.86	n.a.	n.a	52.09	n.a.	n.a.
21	4.76	n.a.	3.42	63.14	n.a.	30.78

[13] See Equation 13 in section 3.3

Table 19 (continued)

22	4.21	3.14	4.53	38.18	27.91	252.92
23	3.92	n.a.	n.a.	27.86	n.a.	n.a.
24	4.22	4.38	3.55	152.60	48.59	254.39
25	4.94	4.39	2.97	116.68	37.69	333.14
26	4.31	3.92	3.68	147.56	48.24	217.77
27	3.88	4.83	2.66	122.58	36.98	120.16
28	5.07	5.12	3.13	137.94	62.26	233.37
29	5.01	4.70	4.04	369.94	82.61	301.80
31	4.44	2.45	4.34	149.19	n.a.	118.62
32	4.90	n.a.	n.a.	57.96	n.a.	n.a
33	5.16	n.a	2.40	64.57	n.a.	27.31
34	4.86	4.20	2.99	154.01	49.31	165.60
35	2.54	n.a.	2.34	n.a.	n.a.	58.94
36	4.00	3.60	3.40	87.88	45.53	163.23
40	3.69	3.27	2.92	20.94	21.48	56.51
41	2.83	2.97	2.98	n.a.	46.48	37.18
51	5.77	5.07	3.50	183.07	232.20	376.17
60	5.00	3.44	2.63	44.22	53.79	147.56
62	5.57	n.a.	n.a.	31.46	n.a.	n.a.
63	4.42	3.85	2.24	43.35	39.13	55.36
64	3.22	1.97	4.62	21.88	23.21	117.44
65	2.48	3.98	4.57	65.26	72.83	109.07
66	3.69	3.06	5.46	61.54	28.42	62.56
67	3.94	2.49	4.92	23.24	39.44	63.05
72	4.03	4.55	4.72	161.45	137.67	314.70
73	3.06	n.a.	n.a.	23.41	n.a.	n.a.
74	2.89	4.15	3.25	33.93	67.94	125.71

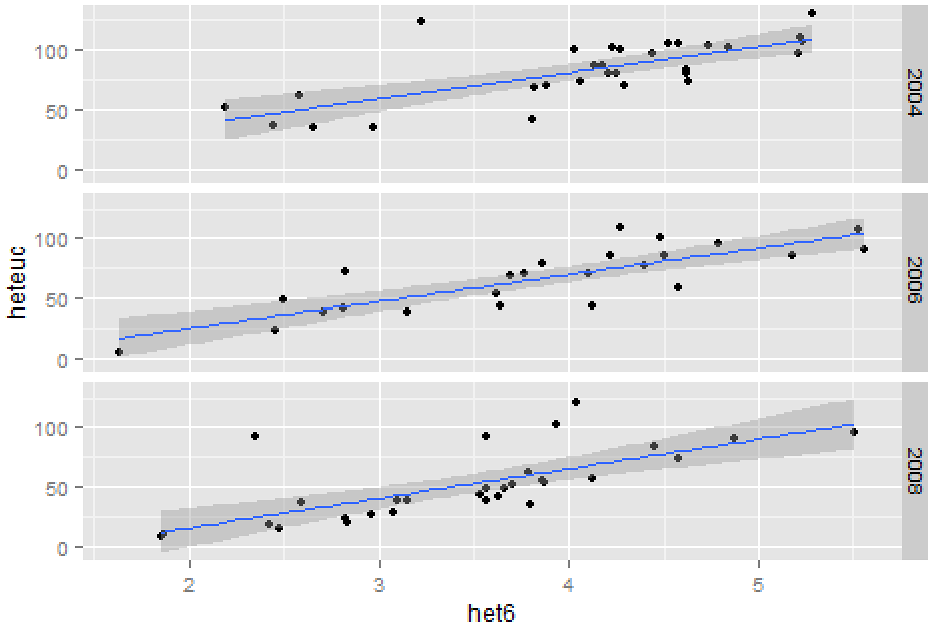


Figure 14 Relation between HET6 and HETEUC

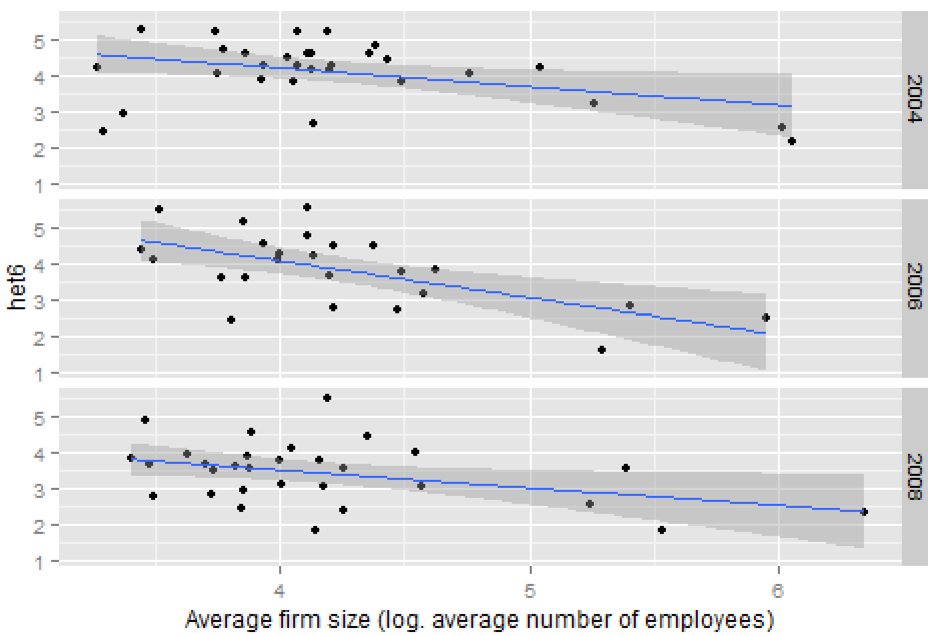


Figure 15 Average number of employees vs HET6

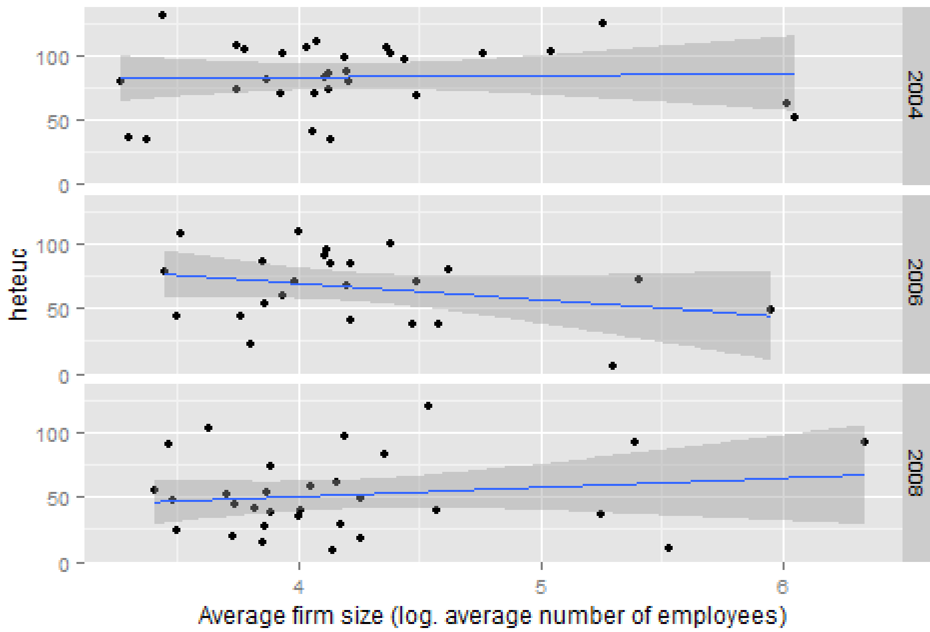


Figure 16 Average number of employees vs HETEUC

Relationship between average innovation expenditure per employee and calculated heterogeneity indices are shown in Figure 17 and Figure 18. Both heterogeneity metrics are positively correlated with sectoral average of innovation expenditure per employee. Higher innovation expenditure can be expected to result in more novelties; therefore this preliminary finding also conforms to the theoretical framework of this thesis and evolutionary literature, which suggest heterogeneity should be higher in environments with high variation.

These preliminary findings suggest that evolutionary processes of selection and variety generation affect the diversity of innovative behavior; therefore a detailed analysis of sources and determinants of intra – industry heterogeneity is required. Next section outlines the regression tree and fixed effects panel data models used for this purpose.

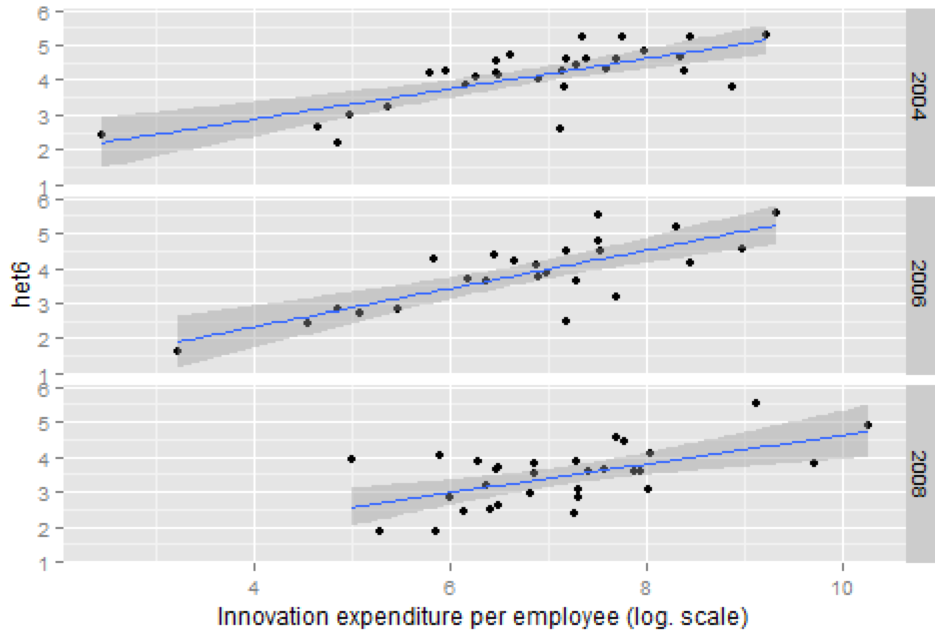


Figure 17 Average innovation expenditure vs HET6

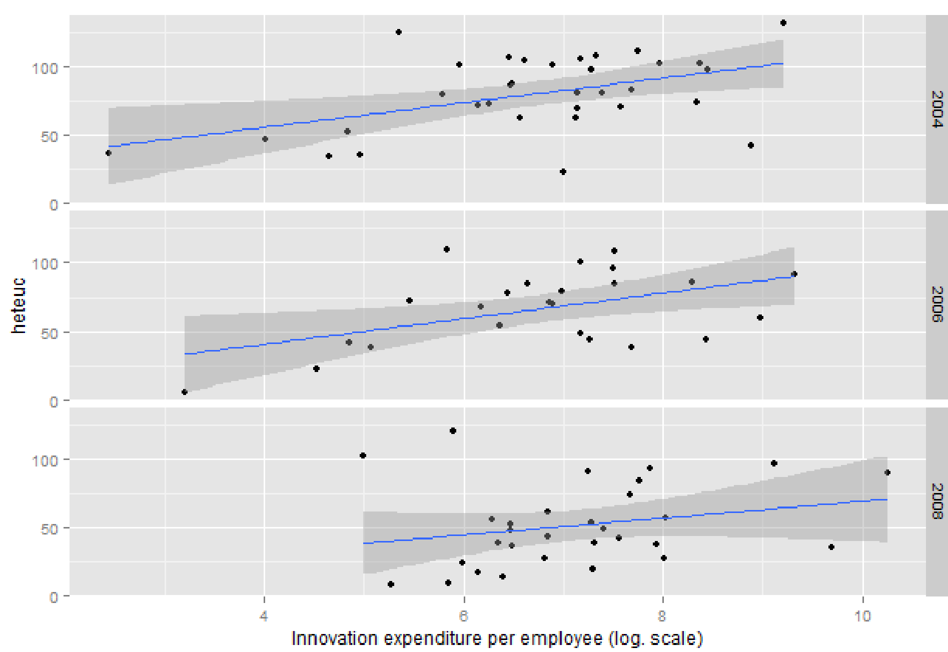


Figure 18 Average innovation expenditure vs HETEUC

5.3 Sector Level Determinants of Intra – Industry Heterogeneity

5.3.1 Methodological Approach

A regression tree model was estimated in order to identify the factors that have a bearing on the amount of intra – industry heterogeneity of innovative behavior. This model is based on the assumption that heterogeneity within an industry is positively correlated with the amount of variety, whereas the severity of selection reduces heterogeneity in that sector. Sector level variables used in the model are described in Table 20. Dependent variables in the models that were constructed for measuring heterogeneity of innovative behavior are the adjusted Simpson Index (HET6) and the average Euclidean distance of factor scores (HETEUC). rpart package for R! was used for the regression tree analysis.

Table 20 Description of explanatory variables and their sign expectation

Variable Name	Description	Sign Expectation
prodin_nf	Share of firms that have introduced a product innovation that is new to the firm	Positive
prodin_nm	Share of firms that have introduced a product innovation that is new to the market	Positive
procin	Share of firms that have introduced a process innovation	Positive
rdin	Share of firms that have in-source R&D activities	Positive

Table 20 (continued)

Rdout	Share of firms that have outsourced R&D activities	Positive
inmach	Share of firms that have investments in new machinery, software systems etc.	Positive/Negative
inexpint	Sector level average of innovation expenditure intensity	Positive
size10	Share of firms that have less than 10 employees	Positive
size1025	Share of firms that have 10 to 25 employees	Positive
size2550	Share of firms that have 25 to 50 employees	Positive
size50250	Share of firms that have 50 to 250 employees	Positive/Negative
size250	Share of firms that have more than 250 employees	Negative
foreign	Share of firms that have foreign affiliation	Positive/Negative
group	Share of firms that belong to a group	Negative
expo	Share of exporting firms	Positive
coop	Share of firms that cooperate in their innovation activities	Positive/Negative

Average firm size is assumed to be an indicator of the degree of competition within an industry. It can be argued that sectors that are mainly populated by small and medium sized enterprises are characterized by Schumpeter's Mark I model. Larger average firm size would indicate dominance of incumbents and a lower degree of competition, which would correspond to the post-selection period of the evolutionary process. This state is compatible with Schumpeter's Mark II model, in which innovation is characterized by gradual improvements. In a different context Fritsch and Andreas (2004) analyze the distribution of technical efficiency within manufacturing industries in Germany and they use a disparity metric to quantify the intra-industry heterogeneity of technical efficiency. Their results indicate that average firm size is negatively correlated with the amount of heterogeneity. Moreover they report that new firm formation rate has a positive effect on the diversity of technical efficiency. Therefore, a higher share of small and medium sized enterprises is expected to increase intra-industry heterogeneity in that sector.

Amount of variety generated within an industry is modeled by the sector – level share of product and process innovators, R&D performers in addition to the average innovation expenditure intensity. Higher average innovation investments within an industry would indicate introduction of new products and processes, which are expected to increase the amount of observed heterogeneity. Fritsch and Andreas (2004) include R&D intensity and share of R&D personnel with a positive sign expectation (i.e. they have a positive effect on the intra-industry heterogeneity of technical efficiency) and empirically verify that human capital intensity is positively correlated with intra-industry heterogeneity.

Embodied technology transfer in terms of acquisition of machinery, software systems and other equipment used in the innovation process may complement intramural research and development activities of firms. Therefore, intra – industry heterogeneity may increase with the share of firms that invest in innovation related machinery and equipment since firm's own efforts to master the embodied technology may result in novel products and processes. Moreover acquisition of such equipment may enable firms to pursue different innovative activities. On the other hand, depending on embodied technology may limit firm's innovation strategies and intra – industry heterogeneity may decrease due to a high number of firms investing in machinery and other innovation related equipment. Therefore, share of firms that invest in innovation related machinery and other systems is included in the models without a definite sign expectation.

Higher share of foreign firms within a sector may exert a competitive pressure on local firms, especially in a developing country context. Local firms, overwhelmed by the competition from foreign firms, may be deterred from undertaking research and development activities. In such a case, overall variety creation in a sector would be negatively affected; thus heterogeneity of innovative behavior should be lower. On the other hand, foreign firms may transfer their technological know-how to their local suppliers, inducing innovative activity within their sphere of influence. Knowledge spillover effects due to employee turn-over, reverse engineering and imitation may also increase the amount of variety within a sector. Therefore, a higher share of foreign firms would also contribute to intra-industry heterogeneity.

Subsidiaries of a conglomerate may enhance their innovative capabilities by accessing to resources of other enterprises in their group (Leiponen & Helfat, 2010). On the other hand, group firms often operate in a correlated way and their course of action is centrally planned. As a result concentration of firms that belong to a group within a sector is expected to diminish heterogeneity of innovative behavior.

Innovative activity within a sector may be stimulated by the so called learning-by-exporting effect. Local firms may improve their product quality and increase their process efficiency, in order to meet up with demands from foreign markets.

Therefore, a higher degree of heterogeneity is expected in sectors with a higher share of exporting firms.

Firms can access novel information through cooperation with their clients, suppliers, universities and other research bodies. Moreover cooperation with other parties would reduce the technical and financial risks associated with innovation. Firms with similar innovative characteristics operating in the same industry are likely to compete with each other since they share a common technology base, which decreases their likelihood of cooperation. In addition, similar firms are less likely to complement the requirements of each other and offer new competences and knowledge for other parties to learn (Luo & Deng, 2009); hence a positive correlation between the sector level share of cooperating firms and intra – industry heterogeneity of innovative behavior is expected. It should be noted that firm similarity in terms of business culture and operational processes may foster trust among cooperating parties (Lui, Ngo, & Hon, 2006); therefore it can be argued that cooperation would be higher in a less diverse industry populated with similar firms. To sum up, a high degree of cooperation within a sector may induce introduction of novelties and increase intra – industry heterogeneity; whereas cooperation is likely to occur between similar entities. Consequently, share of cooperating firms is included in the models without a definite sign expectation.

Panel data models are generally estimated with fixed or random effects. Fixed effects models take into account the presence of unobserved heterogeneity assuming this heterogeneity is constant over time and it is correlated with the independent variables. On the other hand, random effects models employ the additional assumption that individual – specific effects are not correlated with the regressors. Hausman test, as suggested by Cameron and Trivedi (2009) was used for model selection. Preliminary analysis results, shown in Appendix - D did not provide enough evidence to use the random effects model; hence fixed effects estimators were used. In addition to 32 observations shown in Table 13, 15 additional observations were omitted in order to obtain a balanced data set. Final data set consists of 75 sector level observations (25 sector level observations over 3 periods).

5.3.2 Regression Tree Analysis

Regression tree constructed for adjusted Simpson index (HET6) is shown in Figure 19. Recursive partitioning algorithm implemented in the rpart package tries to find the single variable that "best" splits the data into two and ranks each variable included in the model accordingly. Therefore, some variables may be omitted from the constructed regression tree. Recursive partitioning for HET6 included share of R&D performing firms (rdin), firms that invest in innovation related machinery and other equipment (inmach), firms that have a process innovation (procin), cooperating firms (coop) and firms with a foreign affiliation (foreign) in addition to proxies of average firm size in that sector (size10 and size2550).

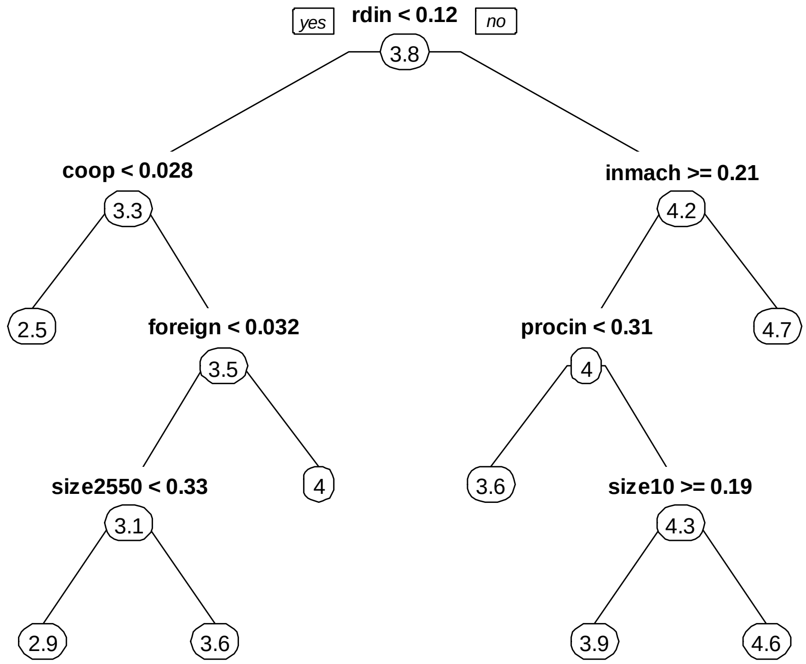


Figure 19 Regression tree analysis for HET6

Similar to classification tree analysis, a rule set can be derived for the regression tree constructed for HET6. Such rules for terminal nodes of the regression tree are listed below:

Rule 1: If ratio of in-house R&D performers is smaller than 12% and ratio of cooperating firms is smaller than 2.8% then HET6 equals 2.5.

Rule 2: If ratio of in-house R&D performers is smaller than 12% and ratio of cooperating firms is larger than 2.8% and ratio of foreign firms is larger than 3.2% then HET6 equals 4.

Rule 3: If ratio of in-house R&D performers is smaller than 12% and ratio of cooperating firms is larger than 2.8% and ratio of foreign firms is smaller than 3.2% and ratio firms with 25 to 50 employees is smaller than 33% then HET6 equals 2.9.

Rule 4: If ratio of in-house R&D performers is smaller than 12% and ratio of cooperating firms is larger than 2.8% and ratio of foreign firms is smaller than 3.2% and ratio firms with 25 to 50 employees is larger than 33% then HET6 equals 3.6.

Rule 5: If ratio of in-house R&D performers is larger than 12% and ratio of firms that invest in advanced machinery and equipment is smaller than 21% then HET6 equals 4.7.

Rule 6: If ratio of in-house R&D performers is larger than 12% and ratio of firms that invest in advanced machinery and equipment is larger than 21% and ratio of firms that have introduced a process innovation is smaller than 31% then HET6 equals 3.6.

Rule 7: If ratio of in-house R&D performers is larger than 12% and ratio of firms that invest in advanced machinery and equipment is larger than 21% and ratio of firms that have introduced a process innovation is larger than31% and ratio of firms with less than 10 employees is larger than 19% then HET6 equals 3.9.

Rule 8: If ratio of in-house R&D performers is larger than 12% and ratio of firms that invest in advanced machinery and equipment is larger than 21% and ratio of firms that have introduced a process innovation is larger than31% and ratio of firms with less than 10 employees is smaller than 19% then HET6 equals 4.6.

Regression tree analysis results for HET6 indicate that heterogeneity due to dispersion of different innovation groups within sectors is mainly governed by the share of R&D performing firms within that sector. This finding conforms to the initial sign expectation. Analysis results indicate that novelties introduced by R&D performing firms contribute to the variety generation process in that sector, which in turn increases the heterogeneity of innovative behavior.

As mentioned in the previous sub-section, embodied technology transfer in terms of acquisition of machinery and other systems may complement firms' own innovation efforts. However regression tree analysis results indicate that heterogeneity of innovative behavior tends to decline when share of firms that have such investments is above 21% within a sector. It can be argued that embodied technology transfer in the form of machinery acquisition deters firms from seeking their own solutions to technological problems; therefore limits the number of innovative strategies. This effect is more pronounced when share of process innovators within a sector is below 31%. On the other hand, intra – industry heterogeneity leans to increase with higher concentration of process innovators and micro – sized firms. Since regression tree analysis results indicate that process innovation adds up to HET6, it can be speculated that learning mechanisms involved in the development of new processes leads firms to adopt different innovation strategies This finding suggests that investments in innovation related equipment coupled with process innovations have a positive impact on the variety generation process in a sector.

Share of cooperating firms and firms with foreign affiliation contribute to HET6 especially when share of R&D performing firms is below 12%. This finding suggests that knowledge exchange between parties in sectors that are characterized by low level of research and development activity is an important source of variety generation. As can be seen in the right branches of the regression tree shown in Figure 19, this effect is more pronounced when the concentration of firms with a foreign affiliation increase in a sector, suggesting that external knowledge flow emanating from foreign affiliated firms induce novelty generation.

According to Taymaz, who analyzed a panel of Turkish firms for the period 1987 – 1997, new entrants to a sector are usually small scale enterprises (2005). Therefore, concentration of small firms may be an indicator of new firm entry rate to a sector. As can be seen in Figure 19, intra – industry heterogeneity is positively associated with the share of small firms within a sector. This finding suggests that new firm entry rate is also influential on the variety generation process.

Regression tree constructed to identify the sources of heterogeneity in terms of average Euclidean distances (HETEUC) is presented in Figure 20. Recursive partitioning for HETEUC included sector level average of innovation expenditure intensity (inexpint), in addition to share of firms with a foreign affiliation (foreign), firms that belong to a group (group) and firms that have introduced a product innovation, which is new to the market (prodin_nm).

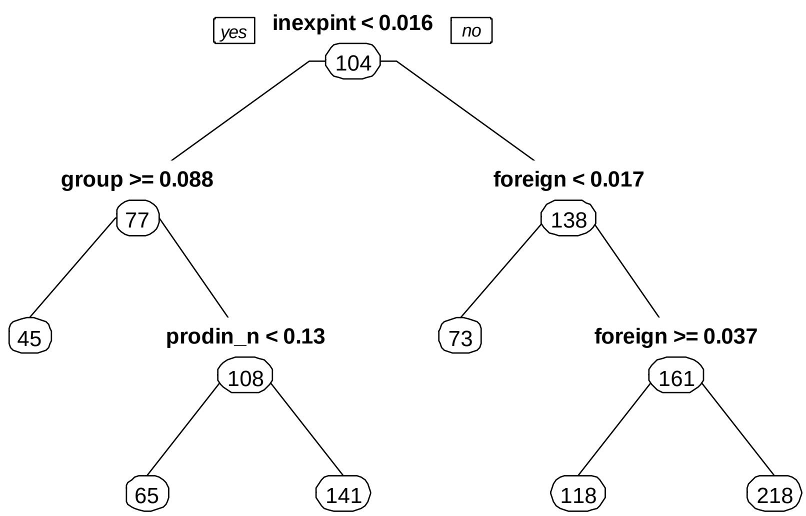


Figure 20 Regression tree analysis for HETEUC

Rule set derived for HETEUC is as follows:

Rule1: If average innovation expenditure intensity is smaller than 1.6% and ratio of firms that belong to a group is larger than 8.8% then HETEUC is equal to 45.

Rule2: If average innovation expenditure intensity is smaller than 1.6% and ratio of firms that belong to a group is smaller than 8.8% and ratio of firms that have introduced a new-to-market product innovation is smaller than 13% then HETEUC is equal to 65.

Rule 3: If average innovation expenditure intensity is smaller than 1.6% and ratio of firms that belong to a group is smaller than 8.8% and ratio of firms that have introduced a new-to-market product innovation is larger than 13% then HETEUC is equal to 141.

Rule 4: If average innovation expenditure intensity is larger than 1.6% and ratio of foreign affiliated firms is smaller than 1.7% then HETEUC is equal to 73.

Rule 5: If average innovation expenditure intensity is larger than 1.6% and ratio of foreign affiliated firms is larger than 1.7% and ratio of foreign affiliated firms is smaller than 3.7% then HETEUC is equal to 118.

Rule 6: If average innovation expenditure intensity is larger than 1.6% and ratio of foreign affiliated firms is larger than 1.7% and ratio of foreign affiliated firms is larger than 3.7% then HETEUC is equal to 281.

Regression tree analysis results for HETEUC indicate that heterogeneity due to the dissimilarity of innovation modes is mainly governed by the average innovation expenditure intensity in that sector. Moreover share of firms that have introduced a new-to-market innovation is also positively associated with HETEUC. Similar to regression tree results for HET6, variables pertaining to the variety generation process increases intra – industry heterogeneity.

A high concentration of subsidiaries within a sector would indicate dominance of standardized practices and limited strategy options. Moreover, subsidiary firms operating under a larger group may be larger than independent firms. Khanna and Yafeh (2007), who analyzed a number of developing countries (including Turkey) report that group firms are significantly larger (in terms of total assets) than independent enterprises. As expected, increase in the share of firms that belong to a group reduces HETEUC.

Effect of foreign ownership is more pronounced for HETEUC than HET6. HETEUC increases as the share of firms with foreign affiliation increases.

Kalaycı (2013) reports that foreign controlled manufacturing firms do not invest in R&D as much as their domestic counterparts in Turkey; whereas domestic enterprises that are spatially proximate to foreign firms benefit from the knowledge spillovers. Foreign firms may have very different innovation practices when compared to their local counterparts; thus an increase in the concentration of foreign firms may induce external knowledge flow into the sector and contribute to the variety generation process. In addition, competitive pressure brought by foreign firms may also force local firms to seek and adopt new business methods thereby increasing intra-industry heterogeneity.

Fixed effects time series models were also estimated to verify above findings. Variable rankings from the regression tree analysis were considered in these model estimations.

5.3.3 Fixed Effect Panel Data Estimations

Estimation results for HET6 (i.e. heterogeneity index based on the dispersion of firms assigned to an innovation group within a sector) are presented in Table 21.

Table 21 Determinants of intra – industry heterogeneity metric HET6 (Period 2004 – 2008)

Variables	Model 1	Model 2	Model 3	Model 4
Average size	-0.664***	-0.663***	-0.658***	-0.590*
	(0.232)	(0.232)	(0.230)	(0.344)
In-house R&D	7.150**	7.129**	7.095**	7.001**
	(2.755)	(2.717)	(2.811)	(2.856)
Cooperating firms	6.605**	6.891**	6.547**	5.061
	(2.957)	(3.137)	(3.012)	(3.712)
Exporting firms		0.650		
		(1.635)		
Machinery expenditure	-4.618***	-4.618***	-4.602***	-4.362**
	(1.568)	(1.596)	(1.565)	(1.613)
Process innovation	6.351**	6.308*	6.317**	6.436*
	(3.030)	(3.077)	(3.036)	(3.194)
Share of foreign firms	11.96***	11.69**	10.72	13.99
	(4.048)	(4.271)	(8.561)	(18.92)
Square of % foreign firms			9.621	29.48
			(53.92)	(57.68)
Size x % of foreign firms				-0.294
				(3.483)
in-house R&D x foreign firms				-24.30
				(26.00)
Year Dummy (2006)	-0.220	-0.254	-0.225	-0.300
	(0.466)	(0.440)	(0.472)	(0.511)
Year Dummy (2008)	-0.398	-0.412	-0.397	-0.413
	(0.304)	(0.297)	(0.307)	(0.311)
Constant	5.176***	5.068***	5.181***	4.781***
	(0.621)	(0.667)	(0.644)	(1.215)
Observations	75	75	75	75
R-squared	0.427	0.429	0.428	0.434

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Variables that were retained in the construction of the regression tree for HET6 were also used in Model 1, which can be considered as the base model of analysis. Firm size was proxied by the logarithm of average number of employees in that sector. In order to investigate the effects of exporting on inducing variety on innovative behavior firms, proportion of exporting firms within a sector was added as an explanatory variable in Model 2. As can be seen in Table 21, proportion of exporting firms is positively associated with intra-industry heterogeneity in Model 2; however its statistical significance could not be verified.

Square of share of foreign affiliated firms was added to Model 3 in order to investigate a U-shaped relationship. Both share of foreign firms and the second order polynomial interaction term have positive signs; however calculated coefficients were not statistically significant.

As outlined in Chapter 3, regression tree analysis can be instrumental in capturing interactions between independent variables. Therefore, interaction terms between share of firms with in-house R&D activities and share of foreign firms, in addition to firm size and share of foreign firms was added to Model 4[14]. Both interaction terms have negative signs, suggesting that increase in the share of foreign firms results in higher levels of intra-industry heterogeneity with sectors that have small average firm size or low number of firms with in-house R&D activities.

Estimation results for HET6 are compatible with the regression tree analysis findings. Share of R&D performers, cooperation and process innovation, which can be related to the variety generation process in the evolutionary framework, contribute to HET6; whereas a higher average firm size significantly reduces it. Share of foreign firms also has a positive impact on intra-industry heterogeneity based on the dispersion of different innovation groups within industries. A u-shaped relationship for foreign ownership could not be verified for HET6. Investment in machinery and equipment significantly reduces HET6 in all models. This finding supports analysis results obtained from regression tree model for HET6. It can be argued that embodied technology transfer in the form of machinery acquisition deters firms from seeking their own solutions to technological problems; therefore limits the number of innovative strategies.

Estimation results for HETEUC (i.e. heterogeneity index based on the average Euclidean distance of factor scores) are presented in Table 22.

[14] Calculation of marginal effects of these interaction terms is given in Appendix – E.

Table 22 Determinants of intra – industry heterogeneity metric HETEUC (Period 2004 – 2008)

VARIABLES	Model 1	Model 2	Model 3
Innovation expenditure intensity	169.7	146.1*	143.4*
	(99.63)	(81.49)	(82.79)
Share of firms that belong to a group	-71.80	-176.4	-198.6
	(237.8)	(214.0)	(219.9)
New-to-market product innovation	102.8	71.56	35.97
	(87.65)	(94.01)	(135.7)
Average firm size			1.064
			(14.08)
Share of exporting firms			-85.54
			(100.3)
Share of foreign firms	-71.09	1,084**	1,130**
	(276.9)	(453.6)	(481.7)
Square of % foreign firms		-9,220***	-9,481***
		(2,349)	(2,516)
Year Dummy (2006)	-34.65**	-36.76**	-36.28*
	(15.18)	(15.66)	(18.95)
Year Dummy (2008)	58.33***	52.80**	50.82**
	(20.25)	(19.83)	(22.37)
Constant	128.2***	120.6**	135.4*
	(44.51)	(44.42)	(75.08)
Observations	75	75	75
R-squared	0.580	0.617	0.621

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Innovation expenditure intensity has a positive impact on HETEUC, though its statistical significance could only be verified in models 2 and 3 respectively.

An inverted U-shaped relationship between foreign ownership and HETEUC was found in models 2 and 3. This finding suggests that increasing presence of foreign firms increases intra-industry heterogeneity up to a certain extent. A number of arguments can be put forward to interpret this outcome. Foreign firms may have distinct innovation practices; therefore their presence in a sector may increase intra-industry heterogeneity. Foreign firms may also exert competitive pressure on local firms, forcing them to seek and adopt new business methods, which may also contribute to intra-industry heterogeneity. However this competitive pressure may also eliminate local firms and reduce intra-industry heterogeneity. Alternatively local firms in the supply chain of foreign firms may adopt their innovation practices, either by knowledge spillover or by contractual enforcements. This alignment of innovation practices may also reduce intra-industry heterogeneity.

Share of firms that belong to a group has a negative sign in all estimated models, though its statistical significance could not be verified. Negative sign for share of group firms confirms regression tree results for HETEUC, suggesting standardized practices and larger size of group firms tend to reduce intra – industry heterogeneity within a sector.

5.4 Concluding Remarks

Primary aim of this section was to examine the determinants of intra – industry heterogeneity at the firm and sector level. Recursive partitioning methods in addition to more conventional regression models were used for this purpose. Theoretical framework of this thesis suggests that a firm's resource base, knowledge sources and relations with other institutions influence its pattern of innovative activities; whereas such patterns are also affected by sector level selection and variety generation mechanisms. Interplay of these mechanisms result in emergence of multiple innovation patterns within industries.

According to Dosi and Nelson (1994) an evolutionary framework should be able to identify some kind of a fundamental unit of selection, such as genes in evolutionary biology. As explained in the previous chapter, innovation patterns of firms may be assumed to be analogous to genes. In addition, an evolutionary framework should also include a mechanism, which connects the genotypic level with the entities. Classification tree method was used to establish the linkage between genotypic and phenotypic characteristics of firms.

Classification tree analysis results indicate that differences in resource endowment, knowledge base and cooperation ability of firms direct them to various innovation paths. Findings from the classification tree analysis show that there are firm level determinants of intra – industry heterogeneity.

Obtained classification tree can be interpreted in such a way that it depicts a dichotomous structure, in which innovation is mainly driven by large firms that have the capability to invest in R&D; whereas small firms display low levels of innovative activity. This finding supports Schumpeter's Mark II model. However latent class analysis results show that there are multiple modes of innovation and classification tree displays the distinction between these modes at its terminal nodes.

Malerba and Orsenigo (1993) suggest that the technological regimes concept put forward by Nelson and Winter (1982) has four main pillars; technological opportunities, appropriability of innovations, cumulativeness of technological advances and properties of the knowledge base. Innovation patterns outlined in the previous chapter can be assumed to be indicators of underlying technological regimes. Sectoral systems of innovation concept put forward by Malerba and Orsenigo (1996) suggests that industries have characteristic technological regimes and firms embedded in these industries behave in correlated ways. On the other hand, classification tree analysis results indicate that firm level factors also have a bearing on innovation patterns.

Dosi and Nelson (1994) also state that an evolutionary framework should include some process of interaction that describes the dynamics of selection and variety generation mechanisms. Theoretical framework of this thesis handles selection and variety generation mechanisms at the sectoral level. Nelson (1995) links the sources of firm heterogeneity within a sector to the interaction between variety generation and selection mechanisms.

According to Malerba (2002) variety generation in sectors may be due to new firm entry, R&D efforts and innovative activities. Results of regression tree and fixed –effects panel models indicate that smaller average firm size, which may be an indicator of new firm entry to that sector, higher share of R&D performing and innovating firms increase intra – industry heterogeneity of innovative behavior.

Regression tree results show that cooperation increases intra – industry heterogeneity especially in sectors with low average innovation expenditure intensity; whereas a high degree of dependence on embodied technologies reduces it. However this effect is less pronounced when investments in machinery and other equipment are coupled with process innovations. Intra – industry heterogeneity tends to increase with higher rates of foreign firm presence within a sector, suggesting external knowledge flow and competitive pressure brought by foreign firms stimulate variety generation mechanisms within the sector. Analysis results indicate that several variety generation mechanisms within industries co – exist, which interact with each other forming a complex system.

Malerba (2002) states that selection is the key mechanism that reduces heterogeneity and it may operate at different levels such as firms, products and technologies. In this sense firm – level competition, consumer preference, and technological race are the main drivers of selection. Moreover government interventions, new institutions and legislations may also induce selective pressure on entities. According to Geels (2004) markets and distribution networks, public authorities, societal groups and users – consumers are the main actors that partake in the selection process. Therefore, selection is a complex concept due to the wide array of mechanisms and diversity of involved actors. In fact, Malerba (2007) asserts that theoretical literature on the selection concept is rather general and detailed analysis of selection mechanisms at the sectoral level and the factors that influence them is required to apply an evolutionary framework to real world problems.

Kwasnicki (1998) reports variety generation and selection as the most important factors that influence the firm size distribution within a sector[15]. Smaller and unproductive firms are eliminated from the market due to selection process; therefore a higher average firm size would pertain to the post – selection period. Average firm size is used to proxy selection intensity at the sector level in models outlined in previous sections. Estimation results indicate that larger firm size is negatively associated with intra – industry heterogeneity.

Empirical analysis presented in this chapter shows that intra – industry heterogeneity is influenced by both firm and sector level factors. Application of recursive partitioning and regression models based on an evolutionary framework partially unveiled the complex structure of variety generation and selection mechanisms, their interactions and their effects on intra – industry heterogeneity. Research findings from Chapter 4 and Chapter 5 show the existence of different innovation patterns within industries and reveal the micro and macro level determinants of such diversity. Following chapter is devoted to the final objective of this thesis, which is investigation of the effects of intra-industry heterogeneity on innovation process.

[15] Relationship between change in the share of innovative firms and intra – industry indices is outlined in Appendix – D.

CHAPTER 6

INTRA – INDUSTRY HETEROGENEITY AND FIRM PERFORMANCE

6.1 Estimation of the Crépon – Duguet – Mairesse (CDM) Model:

Final objective of this thesis is to explore the effects of intra – industry heterogeneity on the innovation process of firms. CDM model provides a sequential framework to analyze this process. A modified version of the CDM model was put forward in OECD's Micro Data Project (Criscuolo, Innovation and productivity: Estimating the core model across 18 countries, 2010). Since analysis is based on firm level Innovation Survey data, framework used in the OECD Micro Data Project is compatible with the scope of this thesis. A common denominator approach was adopted in OECD's Micro Data project, in order to cope with problems related to differences in sampling strategies and sample sizes, inclusion and exclusion of particular questions. Consequently, this model compromises breadth in exchange for comparability. Definition of variables is given in Table 23.

Table 23 Description of variables used in the CDM model

Variable	Definition	Type
LRTOTPE	Logarithm of total innovation expenditure per employee	Continuous
LISPE	Logarithm of new product sales per employee	Continuous
LLPPE	Logarithm of sales per employee	Continuous
SIZE	Logarithm of number of employees in 2006	Continuous
HETINDEX	Adjusted Simpson index / Average Euclidean distance	Continuous
EXPO	Firm's activity in export markets	Binary
GROUP	Firm belongs to a group	Binary
COOP	Firm has engaged in some form of cooperation	Binary
FINGOV	Firm has received some form of public subsidy	Binary
OBS1	Firm has encountered financial obstacles	Binary
OBS2	Firm has encountered knowledge related obstacles	Binary
OBS3	Firm has encountered market related obstacles	Binary
COOP_1	Firm has cooperated with clients	Binary
COOP_2	Firm has cooperated with suppliers	Binary
COOP_3	Firm has cooperated with private research entities	Binary
COOP_4	Firm has cooperated with public research entities	Binary
PROCIN	Firm has implemented process innovation	Binary

However adoption of the OECD model had a restrictive effect on the size and temporal breadth of data. First, innovation survey data for the period 2002 – 2004 (IS4) contained missing sales information for 268 firms and contained observations pertaining to 394 firms with less than 10 employees; whereas such firms were excluded from innovation surveys covering the periods 2004 – 2006 (IS2006) and 2006 – 2008 (IS2008). Second, IS2008 lacked information about impeding factors to innovation; hence variant of the CDM model that was used in OECD's Microdata Project could not be applied for IS2008 data set. Therefore, econometric analysis outlined in this chapter is based on IS2006 data.

Innovation process is modeled in three stages with four equations. In the first stage, firm's decision to invest in innovation and the intensity of this investment was modeled by a Heckman selection model. Second stage represents the knowledge production phase. Estimated values of innovation investment intensity were used to deal with endogeneity issues, which may arise due to unobserved heterogeneity or omitted variables. Four equations describing the three stages of innovation process are outlined in Table 24.

Table 24 Outline of the model specification

Variable	Selection	Intensity	Knowledge Production	Productivity
Innovation dummy	❍			
Log. of innovation expenditure per employee		❍	●	
Logarithm of new product sales per employee			❍	●
Logarithm of sales per employee				❍
Logarithm of number of employees in 2006	✓		✓	✓
Firm's activity in export markets	✓	✓		
Firm belongs to a group	✓	✓	✓	✓
Financial obstacles	✓			
Knowledge related obstacles	✓			
Market related obstacles	✓			
Firm has engaged in some form of cooperation		✓		
Firm has received public subsidy		✓		
Cooperation with clients			✓	
Cooperation with suppliers			✓	
Cooperation with private research entities			✓	
Cooperation with public research entities			✓	
Firm has implemented process innovation			✓	✓
Intra-industry heterogeneity indices		✓	✓	✓
Mill's Ratio			✓	✓
Sector dummies	✓	✓	✓	✓
	Heckman selection model		2SLS instrumental variable regression	

✓ Explanatory variable ❍ dependent variable ● instrumented variable

Wide and strict definitions of innovative firms are adopted in OECD's Micro Data Project (Criscuolo, Innovation and productivity: Estimating the core model across 18 countries, 2010). Accordingly firms that have expenditure on innovation related activities are assumed to be "innovative" in the wide definition. On the other hand, firms that have generated revenue from new products and have innovation related investments are tagged as "innovative" in the strict definition. Model outlined in Table 24 was estimated for both these conceptions.

6.2 Innovation and Productivity – CDM Model

6.2.1 Estimation of the Basic Model

In the first stage, the model proposed in the OECD Innovation Microdata Project was estimated. Obtained results are presented in Table 25 and Table 26 respectively. In the strict definition of innovation, only firms investing in innovation that have introduced a product innovation are considered to be innovative. On the other hand, firms that have innovation expenditure are treated as innovative in the wider definition of innovation.

Propensity to invest in innovation increases with firm size in Turkey. Firms that are part of a group and active in export markets also have a higher proclivity for innovation. As can be seen in Tables 25 and 26, cost related obstacles are positively associated with firm's likelihood of being innovative. However this result should be interpreted with caution. According to Baldwin and Lin (2002) innovators and adopters of advanced technology experience impediments to technology adoption more severely than non-innovators and non-adopters of technology. Similar findings emerge in Catalonia (Segarra-Blasco et al., 2008) and Italy (D'este et al., 2007). These studies contribute to the revealed barriers to innovation concept, according to which, firms that are more immersed in innovative activities experience impeding factors to innovation more severely.

When innovation investment intensity is considered, being part of a group has a significant positive effect on firm's innovation expenditures. Moreover, firms that benefit from public funding programs also outspend their counterparts. However this finding is not sufficient to confirm "additionality" effects of public funding for private innovation efforts.

On the knowledge production side, intensity of innovation investments has a significant positive bearing on revenues generated from new products. Moreover, process innovation contributes significantly to the share of sales from new products to overall sales of a firm, suggesting a complementarity between these two types of innovation.

Model estimates for the last stage show that 1% increase in innovation sales per employee causes approximately 0.8% increase in labor productivity in Turkey. Obtained results show that larger firms are more productive in Turkey. This finding confirms the productivity gap between large and small firms in Turkey (Taymaz, 2005). Process innovation variable in estimations shown in Table 25 and 26 have a negative sign for Turkey, but its statistical significance could not be verified. Although it is possible to quantify the effects of product innovation (in terms of sales) process innovation enters the equation as a dummy variable; hence various aspects of process innovation are neglected. Moreover the basic production function employed in this thesis does not take into account capital and material inputs; hence the omitted variables problem is obvious. Therefore, the effect of process innovation on labor productivity should be verified with a more plausible model.

Obtained results can be compared with other countries, since the methodological approach followed in OECD's Microdata Project is adopted in this thesis. Propensity to invest in innovation increases with firm size in comparison countries. Being part of a group and exporting are also positively correlated with the probability of being innovative (Criscuolo, 2010).

For most of the countries being part of a group, exporting, cooperating with clients, suppliers or research institutes and receiving public subsidies is positively associated higher innovation investment intensity. Cooperation is strongly related to spending on innovation in comparison countries. This effect is most visible in Finland, where firms that cooperate in their innovation activities spend 50% more on the average.

Estimation results pertaining to the knowledge production phase are not tabulated in the OECD Microdata Project report (Criscuolo, 2010). However it is stated that investing in innovation is associated with an increase in sales from product innovation in all countries except Switzerland. However statistical inferences are not available.

Estimation results for the fourth equation, which links innovative activity with productivity, indicate that in all countries, except Switzerland, product innovation increases labor productivity. The magnitude of the coefficients of sales from innovations in the productivity equation ranges from 0.3 to 0.7% in comparison countries.

Process innovation is expected to contribute to labor productivity; however estimation results for OECD countries suggest otherwise. Eight countries report statistically significant negative effect of process innovation on labor productivity. Larger firm size and belonging to a group also positively affect labor productivity in most of the comparison countries.

Table 25 CDM model estimation for strict definition of innovation

VARIABLES	(1) Selection	(2) Intensity	(3) Know.Prod.	(4) Productivity
Log. number of employees in 2006	0.156***		-0.0224	0.128**
	(0.0269)		(0.0937)	(0.0558)
Firm belongs to a group	0.240**	1.032***	0.187	-0.0479
	(0.101)	(0.334)	(0.428)	(0.192)
Firm’s activity in export markets	0.361***	-0.0344		
	(0.0877)	(0.356)		
Knowledge related obstacles	0.153			
	(0.102)			
Market related obstacles	-0.141			
	(0.105)			
Cost related obstacles	0.224**			
	(0.0895)			
Cooperation		0.0118		
		(0.224)		
Public funding		0.681***		
		(0.248)		
Log. new product sales per employee				0.791***
				(0.128)
Process innovation			0.182*	-0.210
			(0.095)	(0.144)
Cooperation with clients			0.416	
			(0.359)	
Cooperation with suppliers			-0.00145	
			(0.418)	
Cooperation with private research entities			-0.0348	
			(0.426)	
Cooperation with public research entities			0.417	
			(0.350)	
Log. innovation exp. per employee			0.724**	
			(0.316)	
Constant	-1.224***	-0.646	10.07***	2.997*
	(0.268)	(1.836)	(1.741)	(1.547)
Observations	1,974	1,974	313	313
R-squared			0.171	0.662

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 26 CDM model estimation for wider definition of innovation

VARIABLES	(1) Selection	(2) Intensity	(3) Know.Prod.	(4) Productivity
Log. number of employees in 2006	0.155***		0.0446	0.117**
	(0.0244)		(0.104)	(0.0584)
Firm belongs to a group	0.241***	1.102***	0.0903	-0.0793
	(0.0923)	(0.312)	(0.438)	(0.191)
Firm's activity in export markets	0.344***	0.355		
	(0.0798)	(0.329)		
Knowledge related obstacles	0.170*			
	(0.0924)			
Market related obstacles	-0.00614			
	(0.0926)			
Cost related obstacles	0.154*			
	(0.0811)			
Cooperation		0.0651		
		(0.187)		
Public funding		0.535**		
		(0.213)		
Log. new product sales per employee				0.808***
				(0.126)
Process innovation			0.202*	-0.209
			(0.108)	(0.145)
Cooperation with clients			0.380	
			(0.359)	
Cooperation with suppliers			-0.0439	
			(0.415)	
Cooperation with private research entities			0.00140	
			(0.422)	
Cooperation with public research entities			0.422	
			(0.346)	
Log. innovation exp. per employee			0.877**	
			(0.377)	
Constant	-1.004***	2.902**	6.849***	4.345***
	(0.259)	(1.413)	(2.282)	(1.225)
Observations	1,974	1,974	436	436
R-squared			0.173	0.656

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

6.2.2 Effects of Intra-Industry Heterogeneity on the Innovation Process

In the next step, heterogeneity indices HET6 and HETEUC were incorporated in the CDM model in order to investigate the effects of intra-industry heterogeneity on the innovation process. Separate models were estimated for strict and wider definitions of innovation and findings are presented in Tables 27 to 30.

Estimation results indicate that HET6 and HETEUC have a positive effect on innovation expenditures of firms. Analysis shows that firms, which operate in more heterogeneous sectors in terms of innovative behavior, tend to invest more on innovation.

On the knowledge production side, HET6 and HETEUC appear to be significantly contributing to sales due to new-to-market products. HET6 has a negative effect on labor productivity, of which statistical significance could not be verified. On the other hand, HETEUC has a positive association with productivity.

Model estimates confirm the findings of Woerter (2009), who also reports that firms in more diverse sectors (in terms of innovative aspects) have larger sales volume due to new-to-market products. Incorporation of variables related to intra-industry heterogeneity did not change the general pattern emerging from CDM model results for Turkey and other OECD countries. As can be seen in estimation results shown in Tables 27 to 30, firm size, being part of a group and exporting are influential on the innovation decision. When innovation expenditure intensity is considered, firms that belong to a group, or receive subsidies for their innovative activities have higher innovation expenditure intensities.

Estimation results indicate that larger firms in sectors with high intra-industry heterogeneity, which have introduced a process innovation, are better at translating their innovation expenditure into sales from product innovations.

Product innovation was still strongly associated with labor productivity, when heterogeneity indices were incorporated in the models. As shown in Tables 29 and 30, sectoral heterogeneity in terms of innovative patterns of firms is positively correlated to labor productivity. Considering the positive effect of intra – industry heterogeneity on innovation expenditure intensity and sales from product innovations, it can be argued that sectors with a diverse innovation base provide a better environment for introducing product innovations and translating these product innovations into higher labor productivity.

Table 27 CDM model estimation with HET6 (strict innovation definition)

VARIABLES	(1) Selection	(2) Intensity	(3) Know.Prod.	(4) Productivity
Log. number of employees in 2006	0.156***		-0.0224	0.128**
	(0.0269)		(0.0937)	(0.0558)
Firm belongs to a group	0.240**	1.032***	0.187	-0.0479
	(0.101)	(0.334)	(0.428)	(0.192)
Firm's activity in export markets	0.361***	-0.0344		
	(0.0877)	(0.356)		
Knowledge related obstacles	0.153			
	(0.102)			
Market related obstacles	-0.141			
	(0.105)			
Cost related obstacles	0.224**			
	(0.0895)			
Cooperation		0.0118		
		(0.224)		
Public funding		0.681***		
		(0.248)		
Log. new product sales per employee				0.791***
				(0.128)
Process innovation			0.182*	-0.210
			(0.093)	(0.144)
Cooperation with clients			0.416	
			(0.359)	
Cooperation with suppliers			-0.00145	
			(0.418)	
Cooperation with private research entities			-0.0348	
			(0.426)	
Cooperation with public research entities			0.417	
			(0.350)	
Log. innovation exp. per employee			0.724**	
			(0.316)	
HET6		0.427**	0.481***	-0.272
		(0.210)	(0.175)	(0.583)
Constant	-1.224***	2.805	4.601**	5.044***
	(0.268)	(1.913)	(2.264)	(1.277)
Observations	1,974	1,974	313	313
R-squared			0.662	0.171

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 28 CDM model estimation with HET6 (wide innovation definition)

VARIABLES	(1) Selection	(2) Intensity	(3) Know.Prod.	(4) Productivity
Log. number of employees in 2006	0.155***		0.0446	0.117**
	(0.0244)		(0.104)	(0.0584)
Firm belongs to a group	0.241***	1.102***	0.0903	-0.0793
	(0.0923)	(0.312)	(0.438)	(0.191)
Firm's activity in export markets	0.344***	0.355		
	(0.0798)	(0.329)		
Knowledge related obstacles	0.170*			
	(0.0924)			
Market related obstacles	-0.00614			
	(0.0926)			
Cost related obstacles	0.154*			
	(0.0811)			
Cooperation		0.0651		
		(0.187)		
Public funding		0.535**		
		(0.213)		
Log. new product sales per employee				0.808***
				(0.126)
Process innovation			0.202*	-0.209
			(0.103)	(0.145)
Cooperation with clients			0.380	
			(0.359)	
Cooperation with suppliers			-0.0439	
			(0.415)	
Cooperation with private research entities			0.00140	
			(0.422)	
Cooperation with public research entities			0.422	
			(0.346)	
Log. innovation exp. per employee			0.877**	
			(0.377)	
HET6		0.497**	0.507***	-0.328
		(0.238)	(0.170)	(0.302)
Constant	-1.004***	2.089	1.985	5.174***
	(0.259)	(1.801)	(2.574)	(1.280)
Observations	1,974	1,974	436	436
R-squared			0.173	0.656

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 29 CDM model estimation with HETEUC (strict innovation definition)

VARIABLES	(1) Selection	(2) Intensity	(3) Know.Prod.	(4) Productivity
Log. number of employees in 2006	0.156***		-0.0224	0.128**
	(0.0269)		(0.0937)	(0.0558)
Firm belongs to a group	0.240**	1.032***	0.187	-0.0479
	(0.101)	(0.334)	(0.428)	(0.192)
Firm’s activity in export markets	0.361***	-0.0344		
	(0.0877)	(0.356)		
Knowledge related obstacles	0.153			
	(0.102)			
Market related obstacles	-0.141			
	(0.105)			
Cost related obstacles	0.224**			
	(0.0895)			
Cooperation		0.0118		
		(0.224)		
Public funding		0.681***		
		(0.248)		
Log. new product sales per employee				0.791***
				(0.128)
Process innovation			0.182*	-0.210
			(0.097)	(0.144)
Cooperation with clients			0.416	
			(0.359)	
Cooperation with suppliers			-0.00145	
			(0.418)	
Cooperation with private research entities			-0.0348	
			(0.426)	
Cooperation with public research entities			0.417	
			(0.350)	
Log. innovation exp. per employee			0.724**	
			(0.316)	
Log. HETEUC		0.246***	2.690***	0.470*
		(0.062)	(0.708)	(0.249)
Constant	-1.224***	3.917**	-0.373	5.048***
	(0.268)	(1.933)	(2.802)	(1.319)
Observations	1,974	1,974	313	313
R-squared			0.171	0.662

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 30 CDM model estimation with HETEUC (wider innovation definition)

VARIABLES	(1) Selection	(2) Intensity	(3) Know.Prod.	(4) Productivity
Log. number of employees in 2006	0.155***		0.0446	0.117**
	(0.0244)		(0.104)	(0.0584)
Firm belongs to a group	0.241***	1.102***	0.0903	-0.0793
	(0.0923)	(0.312)	(0.438)	(0.191)
Firm's activity in export markets	0.344***	0.355		
	(0.0798)	(0.329)		
Knowledge related obstacles	0.170*			
	(0.0924)			
Market related obstacles	-0.00614			
	(0.0926)			
Cost related obstacles	0.154*			
	(0.0811)			
Cooperation		0.0651		
		(0.187)		
Public funding		0.535**		
		(0.213)		
Log. new product sales per employee				0.808***
				(0.126)
Process innovation			0.202*	-0.209
			(0.104)	(0.145)
Cooperation with clients			0.380	
			(0.359)	
Cooperation with suppliers			-0.0439	
			(0.415)	
Cooperation with private research entities			0.00140	
			(0.422)	
Cooperation with public research entities			0.422	
			(0.346)	
Log. innovation exp. per employee			0.877**	
			(0.377)	
Log. HETEUC		0.277***	1.967***	0.481*
		(0.069)	(0.457)	(0.255)
Constant	-1.004***	2.945	-0.790	5.155***
	(0.259)	(1.848)	(2.971)	(1.324)
Observations	1,974	1,974	436	436
R-squared			0.173	0.656

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.3 Concluding Remarks

Research findings presented in this chapter show the complexity of innovation process. Different mechanisms operate and interact simultaneously at various levels. Analysis results show that intra – industry heterogeneity of innovation patterns within sectors has a significant bearing on these mechanisms. Model estimates outlined in sub – section 6.2.2 indicate sectors characterized by versatility of innovation patterns provide a fostering environment for knowledge creation and transformation of knowledge to economic value. However, obtained findings, which pertain to the effects of intra – industry on the innovation process, should be interpreted with caution since metrics of intra – industry heterogeneity are highly correlated with average firm size, innovation expenditure and share of product innovators at the sector level. On the other hand, such multicollinearity should not distort the emerging patterns significantly, as heterogeneity metrics used in the models were calculated at the sector level; whereas firm level data were used for other explanatory variables.

Building upon the empirical findings outlined in this chapter, it can be argued that innovation is characterized by complexity and diversity. Therefore, these essential characteristics should be acknowledged in innovation policies. A critical assessment of existing innovation policy documents in Turkey is provided in the next chapter and a revised policy making process with specific policy recommendations is put forward.

CHAPTER 7

POLICY ANALYSIS

This thesis essentially aims to explore the sources and determinants of intra – industry heterogeneity of innovative behavior and investigate the effects of such diversity on the innovation process. Therefore, empirical analysis is focused on identification of different innovation patterns and exploring firm and sector level determinants of intra – industry heterogeneity. Research findings reported so far in this thesis pertain to heterogeneity at the sector level. On the other hand, diversity of innovation modes can be observed at the regional or national level as well. Consequently, a broader policy analysis, which is not confined to sectoral innovation policies, is provided in this chapter.

Taleb (2007) defines narrative fallacy as the addressing of mankind's limited ability to observe sequences of events without trying to bring an explanation to them; or equivalently forcing logical links upon them. Policy making inevitably requires some form of abstraction such that related information should be ordered, categorized and compressed for future retrieval. In this process, random events may be bound together as if there were some sort of causal relationship between them. For example, the success stories of so called "garage start-ups" may lead to a policy of constructing more garages in order to foster innovation and entrepreneurship. Consequently, there is a need for evidence - based policy making rather than policies built on vague abstractions and narratives.

Analysis results of this thesis show the existence of different types of innovative firms within sectors. This empirical fact suggests that macro or meso level policies should acknowledge the heterogeneity of actors in that particular domain. Specific needs and requirements of different groups, whether they are small non – innovating firms or large multi-national high tech firms, should be taken into account in formulation and operation of innovation policies. In this sense, policy makers should refrain from putting forward idealized innovation modes that are based on stylized typologies and vague abstractions.

Policies built upon narratives tend to force sequential events into patterns. Such patterns make it possible to forecast the future so that policy makers can provide a vision; however such systems are highly vulnerable to random (or unexpected shocks). Moreover, such abstractions reduce innovation to a single dimension, in which actors are either pushing forward, lagging behind or catching up. For example European Union addresses underinvestment in R&D as a major weakness, pointing to the fact that countries such as the USA and Japan are outspending the European Union; whereas developing countries like China are quickly closing the investment gap (European Commission, 2010). Similarly, Supreme Council of Science and Technology has set an ambitious 3% R&D intensity target by 2023 for Turkey (TÜBİTAK, 2011). When innovation is understood as a multi – dimensional exploratory process, then the main argument for policy making goes beyond the typical query of “whether to go forward or not” to searching for alternatives, identifying different interest groups and forming a robust policy base (Stirling, 2011).

In physics, speed is a scalar quantity; whereas velocity is vectoral, which is characterized by both speed and direction. Velocity is defined as the rate of change of position with respect to time. In this sense, the main issues for policy making should be analysis of current position, assessment of alternative positions that can be reached from the current position and the time required to reach to the desired position. Innovation is a complex process, hence innovation policies should adopt a multi – dimensional perspective. Policies built upon a single dimensional view may accelerate innovation efforts very quickly. However, since the outcome of innovation policies cannot be truly predicted, the progress may be in an undesired direction, which cannot be realized until negative effects emerge and the overall system enters into a lock – in state.

For example, Finland's national innovation system, which is characterized by a strong focus on the electronics industry clustered around Nokia had been a major success story (Oinas, 2005; Dahlman, Routti, & Ylä-Anttila, 2006); until Apple and Samsung brought fierce competition to the market. Nokia has been recently sold to Microsoft and many jobs are being redundant. It can be argued that such risks could have been predicted and necessary precautions could have been taken. Because of its high dependence on a single industry (or a firm in this case) Finland's innovation system was in a very vulnerable position and if it had not been from the competition from Apple and Samsung, something else would blow a fatal damage to it.

Consequently, the European Council has advised Finland to broaden and diversify its innovation base in order to reinforce productivity growth and external competitiveness. Finnish government's response to these challenges is to implement policy measures to foster the creation of high-growth innovative firms, which are seen as the major source of employment growth in the future. Tax break schemes for innovative SME's and cooperatives and tax incentives for private investors into start-ups are some examples of such initiatives (European Commission, 2013).

This example shows that Finland's risk exposure was at its peak, when its innovation system was highly regarded as a success story. High performance of ICT sector in Finland shadowed Finnish innovation system's over – dependence on a single industry. As can be seen in Figure 21, Nokia's sales were expected to grow steadily between 2009 and 2012; however, expert views failed to forecast sudden collapse of Nokia's market share. Despite the competence of experts or sophistication of forecasting tools, conventional prediction methods tend to underestimate the effects of "unexpected events". However, such events and shocks have a decisive impact on the long – term sustainability of innovation systems.

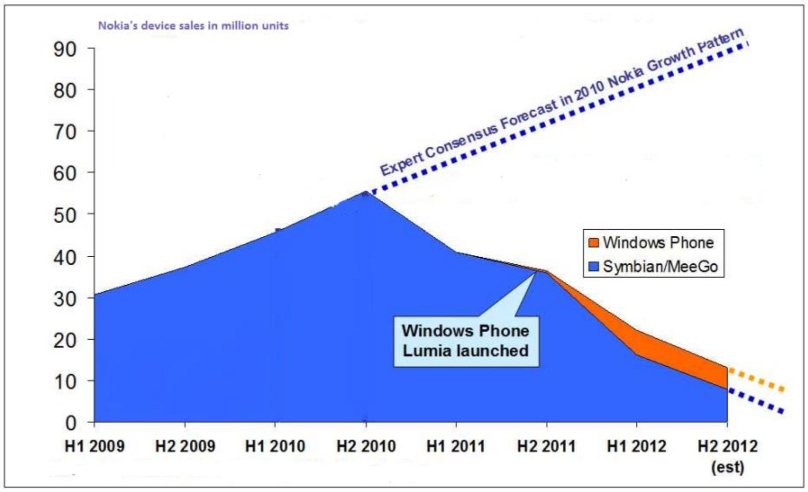


Figure 21 Nokia's sales forecast versus actual performance
(Source: Tomi Ahonen Consulting,
http://communities-dominate.blogs.com/brands/elop/page/2/)

In fact, this problem has its roots in Hume's problem of induction, which underlines the core assumption of uniform behavior of nature. According to Goodman (1983) predictions are justified if they conform to conventional tools of induction; and these tools are valid if they accurately codify accepted inductive practice. Therefore, Goodman (1983) puts forward the concept of projectability, which draws a sharp distinction between coincidental generalizations (i.e. all men in a given room are third sons) and law – like generalizations (i.e. all copper conducts electricity). However generalizations are rarely pure law – like or coincidental in social sciences. Rather they take the form of contingent generalizations (i.e. under a given set of boundary conditions x causes y), statistical generalizations (x increases likelihood of y) or statistical generalizations (Tetlock & Belkin, 1996).

The difficulty of finding robust predicates and asserting their projectability are the main hurdles of decision – making under uncertainty. In this sense, the concept of diversity can be used as a risk mitigation tool to counter the adverse effects of lock – in and path dependency. Consequently, acknowledging heterogeneity of actors, technology patterns and institutions within an innovation system is a precursor of effectively incorporating the concept of diversity into the policy making process. Therefore, a critical analysis of two main innovation policy documents (i.e. “Tenth Development Plan” and “National Science, Technology, and Innovation Strategy”) in terms of addressing the issue of diversity is presented in the next section.

Risk management can be defined as the identification, assessment and prioritization of risks. Risk assessment requires assigning potential loss and probability of occurrence values to specific events. In most engineering systems, rigorous tests are performed in controlled environments; hence probability distribution functions for occurrence and potential impact can be estimated accurately. On the other hand, innovation itself is a problem solving process, which bears uncertainty in its nature. Therefore, diversification, can be a powerful risk aversion strategy for innovation policies, especially for situations that require decision making under uncertainty. However, it should not also be understood as supporting every possible alternative simultaneously. Utilization of diversity in the policy making process involves identification of different paths (rather than imposition of an idealized state), pursuing different alternatives that have the least risk of lock – in, and mediating the conflictions arising from these alternatives. Therefore, a revised policy framework is proposed in section 7.2. Based on this perspective, this chapter is concluded with some policy recommendations that aim to increase the resilience of the innovation system in Turkey by fostering the diversity of actors and innovation modes.

7.1 Analysis of Current Policy Documents

Development plan documents have guided science, technology and innovation policies in Turkey since 1963. “Innovative Production, Stable High Growth” is one of the main pillars of the Tenth Development Plan, which covers the period 2014 – 2018. Aim and objectives of science, technology and innovation policies under this pillar are defined as fostering technology and innovation activities with a focus on private sector, commercialization of research outputs within an innovation based ecosystem and contributing to Turkey’s international competitiveness with technology-intensive product development (Ministry of Development, 2013).

There are thirteen policy measures under Science, Technology and Innovation topic, most of which are related to enhancing the collaboration between private sector, academic and public institutions; suggesting the influence of the “triple helix” concept (Etzkowitz & Leydesdorrf, 2000) on these policies. Moreover, clustering and networking emerge as other priorities of science, technology and innovation policies.

Article 633 in the Tenth Development Plan is of particular interest within the scope of this thesis since it suggests policies towards focusing research centers, incubation centers, technology transfer offices and technology development zones. Moreover, one of the aims of Program 1.11 – Commercialization Program in Priority Technology Areas is sectoral specialization of technology development zones. It can be argued that main rationale behind this policy recommendation is to benefit from Marshallian externalities by bringing together similar firms, which share a common resource base and operate on the same technological trajectory. Empirical findings from this thesis suggest that diversity of innovative aspects provide a better environment for innovation investments and product innovations. Therefore, policies towards clustering should focus on the value chain created by diverse actors, rather intensifying the proximity of similar entities.

Transformation of Manufacturing Industry is another topic under the Innovative Production, Stable High Growth Pillar in the Tenth Development Plan. Analysis of the current situation and policy recommendations under this topic only distinguish between large and small firms. Moreover, export performance of medium – technology and high – technology sectors are compared. Heterogeneity of firms and sectors are addressed based on their size and technology intensity respectively (Ministry of Development, 2013). Empirical findings from this thesis indicate that size may be an indicator of firm's innovation pattern but multiple patterns exist. Consequently, policy recommendations using classifications solely based on firm size (i.e. SME vs large firms) and technology intensity (low – tech vs high – tech sectors) are too broad and general. For example Article 662 in the Tenth Development Plan suggests policy measures to foster pre-competitive innovation networks and joint R&D undertakings of firms. According to Dyer and Singh (1998), collaborating firms should be spatially proximate and possess complementary assets and human resources. Therefore, solid policy incentives towards fostering R&D networks and collaboration require addressing of heterogeneity of the actors.

There are eleven policy recommendations under the Entrepreneurship and SME's topic. Article 694 recommends developing private investment schemes such as venture capital, angel investment, and micro-credits to fund SME's and new enterprises (Ministry of Development, 2013). Emphasis on enabling private investments to high growth innovative new enterprises in order to diversify national innovation system, such as the innovation policies pursued by Finland as mentioned above, is missing in the Tenth Development Plan. On the other hand, Article 695 puts forward policies to support research, innovation, and export capacities of SME's. As reported in sections 4.1 and 4.2, all SME's are present in all classes, which have very distinct innovative characteristics. Consequently, effective mechanisms to support SME's call for addressing the differences in their innovation characteristics. In this sense, detailed analysis of drivers and enablers of innovation is a prerequisite for effective innovation policies, which target SME's. Moreover, factors that hamper innovation in SME's should be scrutinized. Firms with distinct characteristics may have different requirements for innovation policies. For example, financial incentives may provide input additionality for some SMEs, whereas policy actions towards increasing demand for innovative products may result in output additionality for other groups.

Tenth Development Plan acknowledges the concept of *diversity* as a risk mitigation tool for a number of policy issues (e.g. diversification of financial tools to promote private savings, diversification of export markets to reduce the vulnerability of manufacturing industries). Moreover, Article 919 under Regional Development and Competitiveness topic suggests policy measures for sectoral diversification in medium – income regions (though a justification for why such diversification should be limited to medium – income regions is not provided) (Ministry of Development, 2013). However the existence of distinct innovation patterns within industries and the effects of heterogeneity due to differences in innovative aspect of firms are not acknowledged in the Tenth Development Plan. This broad perspective regarding the innovation process can be plausible since the Tenth Development Plan is a high – level document providing a guideline on main policy directions and addressing specific action plans to other policy documents.

"National Science, Technology, and Innovation Strategy 2011 – 2016", which was endorsed by the Supreme Council of Science and Technology in its 22nd meeting held on 15th December 2010, has three vertical pillars; namely i) Mission – oriented approaches in areas with strong R&D and innovation capacity, ii) Need oriented approaches in areas with a demand for gaining acceleration, iii) Bottom – up approaches including basic, applied, and frontier research. Action plans aiming to achieve the targets set in these vertical domains are grouped under six vertical domains. (TÜBİTAK, 2010).

After a sector level analysis of R&D spending, number of full-time researchers, in addition to export and import figures, automotive, machine manufacturing, and information and communication industries are designated as “areas with strong R&D and innovation capacity”. “Areas with a demand for gaining acceleration” were determined by the Supreme Council of Science and Technology Council with its decree no. 2010/101 (TÜBİTAK, 2010). Health sector was added to the initial five domains (i.e. defense, space, energy, water, and food sectors) by the Supreme Council of Science and Technology with its decree no. 2013/106:

Similar to the Tenth Development Plan, National Science, Technology, and Innovation Strategy 2011 – 2016 document treats industries as monolithic structures. Prioritization process outlined in the document embodies a detailed analysis step (TÜBİTAK, 2010, p. 17). Moreover, Strategy D.1.1.1 states performing detailed sectoral analyses covering sub-sectors as well; however actions planned for 2014 under this topic (formation of a regulatory framework for convergent telecommunication services and preparation of a research and innovation strategy document for information and communication technologies sector) provide little insight about the distinct patterns of innovation within an industry.

“National Energy R&D and Innovation Strategy” document, which is an annex to the 2011 – 2016 strategic plan also hovers around the concept of *diversity* by mentioning the importance of diversification of energy resources but the National Science, Technology, and Innovation Strategy 2011 – 2016 does not acknowledge distinct innovation patterns within industries. On the contrary, an idealized innovation process, which focuses on high – technology investment, university – industry cooperation and linkages with international networks is implied in the document. This approach has two main drawbacks: First, there are multiple patterns of innovation observed in industries. Policy instruments outlined in the 2011 – 2016 strategy document are either aiming firms that match the idealized innovation typology or direct other firms to align their innovation activities with the *politically correct* pattern. Second, the 2011 – 2016 strategy document does not provide a contingency plan against the risks associated with favoring a certain type of innovation pattern or prioritizing certain sectors and technologies.

Analysis results indicate that intra – industry heterogeneity has a positive influence on innovation investments, introduction of product innovations and (to some extent) labor productivity. Wrong way of interpreting this "fact" is to fall into the narrative fallacy trap and seek for policies to establish "optimum" heterogeneity within sectors. Innovation policies should aim to reduce vulnerabilities in the innovation system in order to ensure long – term growth and sustainability. Such robustness can be attained by active policies that support heterogeneity in the (national, regional, sectoral) innovation system, or by avoiding policies that lead to highly fragile singular solutions. Building upon the empirical findings documented in this thesis and the critical analysis of the existing policy documents, which govern the innovation policies in Turkey a revised policy making process is put forward in the next section.

7.2 Revision of the Policy Making Process

According to Kay (2006) "policies cannot be analyzed apart from the policy making process". Therefore, this section puts forward a policy framework with the concept of diversity at its core.

Morlacchi and Martin (2009) assert that the creation process of science, technology and innovation policy issues is as much important as deciding how these problems can be addressed. According to Kingdon (1984) at any given time, policy domain contains a variety of ideas, which compete in a complex selection environment. When a “policy window” opens, specific ideas that make it through the selection process come to prominence. Kingdon (1984) argues that influx of policy issues from this window of opportunity combines gradual and incremental evolution with punctuated equilibrium. Slembeck (1997) analyzes political change from a Schumpeterian view and argues that creative destruction of existing policies is followed by an institutional arrangement that reinforces the emerging policy themes. In Turkey, emphasis shift from quality oriented policy measures (e.g. Turquality program) to pro – innovation policies and finally to technology oriented entrepreneurship is an example of such cyclic policy change.

Similar to Schumpeter’s entrepreneur, Kingdon (1984) suggests that exploitation of new opportunity windows or focus change in the policy domain are contingent on the actions of “policy entrepreneurs”, which are actors that have substantial benefit in the enactment of a specific policy. Flanagan et al. (2011) define “interest networks” as groups of actors that participate more frequently and more directly in the policy making process; whereas actors in “discourse communities” are relatively dormant. According to Howlett and Ramesh (2003) in a policy subsystem, *relevant* actors discuss policy issues and use persuasion and bargaining methods to reach their goals. Therefore, identifying the relevancy of actors partaking in the policy making process is a crucial issue.

Moreover Laranja et al. (2008) assert that policy makers utilize theoretical aspects of innovation policy in a selective manner to justify their actions, and often policy maker’s norms, beliefs and goals shape the specific course of action. Effects of special interest groups and policy maker’s preferences on the policy making process can be seen in the preparation of the “National Science, Technology, and Innovation Strategy 2011 – 2016”.

Actors that participated in preparation of the “National Science, Technology, and Innovation Strategy 2011 – 2016” are listed as representatives of public authorities, members of TÜBİTAK’s Science Board, TÜBİTAK Science Award laureates, representatives of private firms that have extensively benefited from TÜBİTAK’s funding programs and affluent researchers that have international reputation.

It can be argued that the policy maker (TÜBİTAK in this case) assured the participation of a wide variety of actors to the policy making process. On the other hand, it is clear that the policy maker has an a priori “typology” of the actors in the science, technology and innovation landscape in Turkey. For example in the preliminary workshops, private sector was represented by firms that had been intensively funded by TÜBİTAK. This preference indicates that policy maker relates the amount of funding it provides to private firms as a measure of their innovativeness; hence views them as *relevant actors* of the innovation system. Similar argument can be put forward for the large and diverse community of researchers, who are only represented by a small number of high profile individuals.

Classificatory analysis results of this thesis show that there are groups of firms with different innovation modes. Analytic scope of this thesis is confined to the exploration of innovation patterns within firms; however obtained findings indicate that other actors of the innovation system (i.e. public bodies, universities, research institutions, individual researchers, entrepreneurs, customers etc.) may display substantial heterogeneity as well. Excluding some of these groups from the policy inception phase, without a soundly falsifying their relevancy in the innovation system, may lead to policies biased towards certain interest groups. Policy maker’s rationales and priorities of interest groups may turn into a self – reinforcing structure, which in turn may lead to a lock – in situation.

As an example, policy makers may reduce innovation policies to a single dimension (i.e. going for “pro-innovation” policies that aim to lead, catch-up or leapfrog in a single track race) and favor tools that stimulate R&D spending; whereas actors that seek additional resources for R&D investments may demand and encourage implementation of such tools. However increasing R&D investments with intense public funding for R&D activities also bears the risk of making actors of the innovation system over dependent on subsidies and reaching to a state, in which innovation activities cannot be sustained without further subsidization. Withdrawal of public funding (due to unforeseen events such as financial crisis, or policy shift) may lead to an overall failure of the system. As this semi – hypothetical example demonstrates, feedback mechanisms in the policy making process may lead to an irreversible path dependency, which in turn drives the whole system to a fragile state. Therefore, policy framework put forward in this thesis aims to eliminate path dependency related risks that arise from the imposition of abstractions derived from a single dimensional view of innovation. In this context, the concept of diversity is used as an institutional level safeguard against path – dependency and lock – in. In fact, essence of the suggested policy framework has common grounds with Israel’s intelligence and espionage practices. Israeli intelligence agencies failed to foresee the approaching attack by Egypt and Syria in the 1973 Yom Kippur War. This failure led to a series of reforms in Israel’s intelligence agencies. One of the policy actions was establishment of the *devil’s advocate office* within the Directorate of Military Intelligence (AMAN) to ensure creativity of intelligence assessments that do not succumb to group thinking. This office regularly criticizes assessments from other divisions and writes position papers that counter the views of other departments (Kuperwasser, 2007). Suggested policy framework acknowledges the heterogeneity of actors and fosters diversity of innovation practices as a risk mitigation tool.

Advocated policy framework suggests thorough analysis and critique of national, sectoral or regional innovation systems as a starting point in order to comprehend underlying complex and dynamic interactions of actors and mechanisms, instead of depending on typologies that are contingent upon aggregated characteristics such as sector level average of R&D spending. Identification of different actors and their governing dynamics within an innovation system has a significant bearing on the policy making process.

First, as explained in the “relevancy” discussion above, innovation policies should be built on the consensus of a broad base of actors including public bodies, firms with different innovation characteristics, research institutions, labor unions, financial institutions, individual researchers as well as citizens[16]. Active participation of a wide variety of actors is expected to counter the self-reinforcing mechanisms that would create path dependency and cause locking – in.

Secondly, detailed analysis of interactions between actors of the innovation system and governing mechanisms such as knowledge generation, demand creation, cooperation and competition is expected to provide more sound policy rationales that take into account drivers, enablers and impeding factors pertaining to the innovation process.

Once actors of the innovation system are distinguished and sound policy rationales are put forward by their active participation, target groups and beneficiaries of potential policy measures should be identified. As the analysis results of this thesis demonstrate, it is not possible to establish comprehensive policies with aggregated characteristics. Aforementioned systemic analysis of innovation systems should be instrumental in categorization of potential target groups and beneficiaries and reflecting their varying characteristics.

[16] For example the VOICES (Views, Opinions and Ideas of Citizens in Europe on Science) project aims to engage citizens of the European Union in shaping the science, technology and innovation policies. "Urban waste as a resource" was chosen as the pilot theme of the project and project reports reflecting the view, opinion and ideas of 1000 citizen’s were used to draw up a number of research calls for the EU’s Horizon 2020 funding program. See http://www.voicesforinnovation.eu for more details.

Another important aspect of the policy making process is gathering and analyzing requirements, which involves identification of needs in the problem domain, features of the viable solution options and operational requirements such as budgetary arrangements and human resource allocation. Requirement analysis steps in this context are outlined in Figure 22.

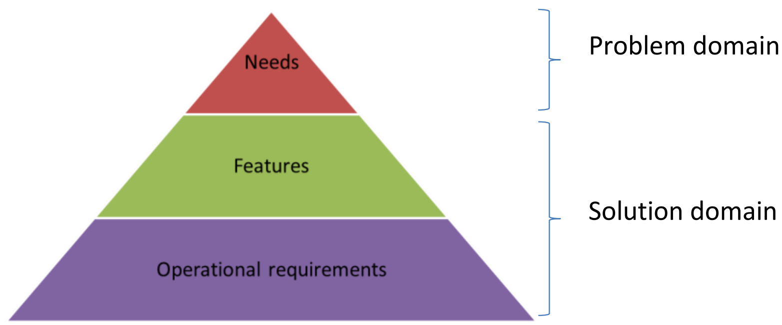


Figure 22 Phases of requirement analysis

Policy rationales draw the boundaries of the problem domain; whereas identification of specific needs of actors within the innovation system provide the substance that enables drawing a set of tools from readily available solutions or formulating new ones. In this sense functional requirements reflect perception of drivers, enablers and barriers in the specific problem domain from different perspectives. Depending on the policy rationales and functional requirements, performance requirements, which can be used for impact assessment of policy tools, should also be put forward.

A distinguishing aspect of the proposed policy framework is the integration of diversity based risk avoidance and mitigation mechanisms to the policy making process. Conventional risk assessment tools attempt to assign a quantitative (probability of occurrence) or qualitative (high or low) value to the incidence of a specific event or a recognized threat. Calculation of the magnitude of the potential loss and the probability that the loss shall occur is an essential part of conventional risk assessment methods. If the cost of an effective counter measure is estimated to be higher than the expected loss, then the risk is designated as "acceptable". If an analogy between risk management and natural sciences is established, then events that pose "risk" can be related to "stressors"; whereas occurrence of such events results in "stress formation" in the system. In this analogy, risk management deals with "stress tolerance" of the system.

In mechanics of materials, stress is defined as a measure of the internal forces acting on a body. In an equilibrium state, the integral of internal stresses is equal to the external forces applied to the body (or a system). In this sense, internal forces in a body (i.e. stress components) occur as a reaction to external forces (i.e. stressors).

In addition to mechanics of materials, the concept of stress is also used in biology. Selye (1973) defines stress as the non – specific response of the body to any demand made upon it. According to Selye (1973) stress is essentially related to readjustment and adaptation of organisms to perturbations created by stressors; hence it is non – specific to the type and intensity of external disturbances. Kovalenko and Sornette (2013) suggest that such non – specific response (or symptoms of stress) to a new demand exerted by a stressor in biological organisms and socio – economical systems follows a sequential process, which involves increase in attention, mobilization of resources, concentration in key areas and recovery or exhaustion of the adaptive response and transition to a crisis state. Final stage is similar to the elasto – plastic behavior of materials in physics. Material returns to its original state upon removal of stress in the elastic range; whereas when the stress exceeds the elastic limit, the material deforms non – reversibly and finally fractures. In biology, temporary perturbations that do not exceed the natural regulatory capacity of the organism are tolerated and homeostasis is sustained. On the other hand, unrelieved stress may lead to pathological states.

In mechanical systems, it is possible to directly observe the stress – deformation relationship. Similarly response of organisms to certain stressors can also be observed in biology. On the other hand, direct observation of exogenous forces and their effects on a socio – economic system is not possible due to complexity of relations and interactions between the actors of the system. Therefore, probabilistic methods that introduce metrics for risk assessment are used to quantify stress levels. However, in most real world problems, it is not possible to assign probabilities to outcomes, or define a comprehensive set of consequences. On the other hand, suggested policy framework has a precautionary stance and it should include mechanisms that opt for recognition of attributes, which may lead to sudden and catastrophic failure due to unforeseen events. This perspective is more concerned with uncertainties brought about by interventions, rather than assigning arbitrary occurrence probabilities and estimating unrealistic loss functions.

As described above, risk pertains to the characteristics and magnitude of stressors; whereas resilience can be defined as the amount of stress that a system can bear without undergoing a significant transformation. Consequently, risk mitigation strategy and selection of appropriate policy tools involves combining solutions that are likely to increase the overall resilience of the system by prioritizing more flexible alternatives over less reversible ones. However, resilience in this sense should not be understood as a relentless effort for sustaining the status quo. A resilient system should be able to cope with stresses within its limits and use them as guiding signals for transformation and adaptation to altering conditions (Sotarauta & Srinivas, 2006). Building up resilience by increasing reserves, developing excess capacity, creating redundancy and allowing multiple alternative paths to emerge is a key feature of the proposed policy framework.

According to Kovalenko and Sornette (2013) increasing the resilience of a system requires continuously inquisiting and criticizing existing practices, almost with a “paranoid obsession that things could go wrong, when everything appears to be fine”. Therefore, impact assessment of implemented policy actions is an essential element of the suggested policy framework, which prioritizes building up resilience over short term opportunistic gains. In this sense, impact assessment should ensure transparency and accountability of innovation policies. Moreover negative effects of lock – in due to path dependency may be eliminated by thoroughly scrutinizing functional and performance features of selected policy actions.

Cyclical structure of the suggested policy framework, which puts the concept of diversity at its core, is outlined in Figure 23. Diversity appears as the most essential element of this framework in a number of ways. First, identification of *relevant actors* within an innovation system requires addressing heterogeneous characteristics various entities in addition to micro and macro level factors that generate (or reduce) such heterogeneity. Embracing the variety of actors in the innovation landscape, instead of imposing typologies that depend on assumptive beliefs of policy makers and incentives of a few select interest groups, is expected to democratize the policy making process. Furthermore, addressing heterogeneity of actors and patterns in the innovation process also calls for a detailed analysis of drivers, enablers and impeding factors of innovation, which can be used to identify functional and performance requirements for policy actions and clear policy targets. Second, allowing multiple innovation patterns to emerge or deliberately fostering multiplicity in the innovation landscape is expected to increase the overall resilience of the system. As outlined in the previous section, current innovation policy practices that depend on idealized innovation patterns often neglect the risks brought about by path – dependency and lock – in. However policy framework advocated in this thesis is equally distant to such negligence and probability based risk assessment and mitigation methods. Probability based risk assessment methods are susceptible to unintentional binding of random events. Therefore, predictive models that are used to estimate loss functions generate fairly stable results for events that are characterized by well-defined probability distributions; whereas the impact of incidents that are otherwise regarded as outliers is generally higher than calculated expectations and in fact, such incidents make the real difference. On the contrary, resilient systems that are fostered by diversity - based policies are strengthened by variations within its tolerance limits and may adapt to altering conditions without sudden and catastrophic failures. Consequently, policies that allow emergence of a diverse palette of innovation patterns should contribute to resilience building within a system to ensure sustainability and long term growth. On the other hand, there is a trade – off between obtaining fast results in the short term by favoring singular solutions and allocating resources for building up resilience within a system. As pointed out by Weitzman (1992) policies that allow for pursuing multiple alternatives create extra costs. However such burden can also be considered as an insurance premium for hedging against the risks due to path dependency and lock – in. In this sense, finding a balance between short term incentives and long term capacity building is the main challenge for policy makers, which can be mediated by broadening the policy base and ensuring active participation of all actors in the policy - making process.

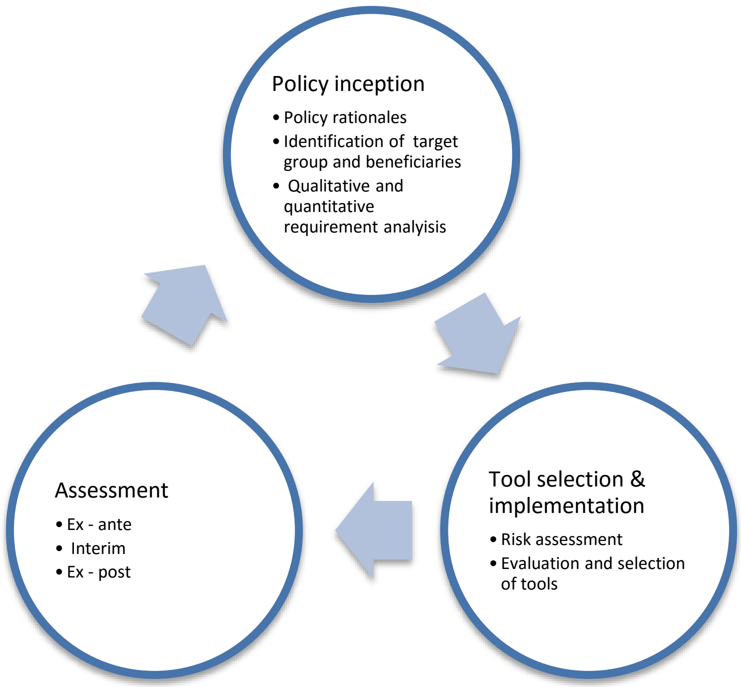


Figure 23 Suggested framework for innovation policies

Analysis of existing policy documents pertaining to the innovation system in Turkey shows that policies implemented by various public authorities have some major setbacks. First, policy actions and strategies that are reviewed in section 7.1 depend on assumptive typologies put forward by policy makers. On the other hand, research findings of this thesis indicate that firms display a multitude of innovation patterns; hence distinctions based on sectoral affiliation or firm size are not sufficient to comprehend specific needs and requirements of firms that are within the scope of a particular policy action. Policy making process should start with a detailed analysis of actors and identification of drivers, enablers and barriers to innovation for firms with distinct innovative characteristics. In this sense, policies that are built on the narrow interests of a few select interest groups tend to create fragmentation in the policy landscape. Therefore, the first suggested policy theme is labeled as "coherence of innovation policies". In this sense, policy making process should be revised and fewer policy actions with broad coverage should be preferred over numerous measures that have limited scope. For example TÜBİTAK, Small and Medium Enterprises Development

Organization (KOSGEB) in addition to Ministry of Science, Industry and Trade and Ministry of Transport, Maritime Affairs and Communications all operate research and development support programs that have overlapping scopes. On the other hand, specific needs of firms with different innovation characteristics are often overlooked. Consequently, policy measures can be simplified while their content and scope are adjusted for a broader coverage.

Second, a distinction between chronic and acute problems is not present in current innovation policies. Chronic problems may lead to systemic failures and overall dysfunction of the system; whereas acute problems within the tolerance limits of the system may be resolved over time without any intervention. Proposed policy framework suggests that overall resilience and stress tolerance capacity of an innovation system can be enhanced by fostering diversity. In this sense, policy makers should distinguish between chronic and acute problems in the innovation system and should use perturbations within the system as guiding signals towards policy change.

This thesis suggests that existence of multiple patterns within an innovation system increases its resilience and stress tolerance capacity. As pointed by obtained research findings, diversity is related to the variety generation and selection mechanisms within an innovation system. Creation of new firms contributes to variety generation mechanisms; hence supporting new technology based firms can be instrumental in diversification of an innovation system. Recently, new technology based firms and technology based entrepreneurship have been the target of great expectations. Current policies that aim to promote new technology based firms adopt a typology, which is heavily influenced by the rapid growth of start – ups in Silicon Valley. This single – dimensional perspective dictates entrepreneurs to fit in a certain pattern. On the other hand, suggested policy framework views such firms as repositories of technology and knowledge. Some start – ups may follow a rapid growth path, whereas others may find profitable niche markets and deliberately remain small. Therefore, function of a start – up within an innovation system and its position in a value chain are more important than its growth potential; since innovations brought about by small new technology based firms may induce growth and productivity increase in other domains of the system. Consequently, support for new firm creation is an essential part of the suggested policy framework since new technology based firms are expected to contribute to variety generation by introducing innovative products and processes and challenging incumbent firms. Different functions that can be performed by new technology based firms should be taken into account in formulation of policy measures to support technology based entrepreneurship.

New firm formation is an important element of variety creation within a system. On the other hand, empirical findings from this thesis show that diversity of innovative behavior within a sector is also strongly related to average innovation expenditure and introduction of new products. In this context, systemic problems that hinder innovation process within a system should be removed in order to stimulate innovation related investments.

Empirical analysis results also indicate that heterogeneity within a sector is positively correlated with the share of collaborating firms, and this effect is more pronounced in sectors that have low average innovation expenditure intensity. In this context, sectoral and regional clusters and collaboration networks should be supported in order to promote different innovation patterns and increase resilience. Analysis results show that influx of external knowledge brought by foreign firms contributes to variety generation mechanisms within a sector. Therefore, linking local firms to the innovation value chain of foreign affiliated firms is expected to contribute to intra – industry heterogeneity.

Building upon the empirical findings reported in this thesis and suggested policy framework, some policy recommendations towards increasing the resilience of the innovation system in Turkey by fostering diversity are outlined in Table 31.

Table 31 Outline of suggested policy themes and measures

Policy Theme	Status Quo	Suggested Measures
Coherence of innovation policies	- As described in section 7.1, current innovation policy documents are based on idealized innovation patterns and do not discriminate between random and temporary perturbations, which can be overcome by self-alignment and organization of actors within the influence sphere of policies and systemic failures that exceed the resilience capacity of the innovation system.	- Innovation policies at any level should be built on comprehensive analysis of drivers, enablers and barriers to innovation and should identify the needs and requirements of various actors within that system, since policy measures that favor singular solutions may turn into stressors in the long term. Consequently, fewer policy measures with broad coverage should be preferred over implementation of numerous policy actions with narrow scope. - Innovation policies should aim to resolve systemic failures, which may lead to chronic distress or overall failure of the system; whereas perturbations that can be tolerated without further intervention should be closely monitored and utilized as guiding signals for transformation and adaptation to altering conditions.

Table 31 (continued)

Diversification of innovation base by supporting new technology based firms	- Ministry of Science Industry and Technology, TÜBİTAK and Small and Medium Enterprises Development Organization operate direct grant programs in addition to training and mentoring schemes; which are not essentially different. Influenced by the success stories of mainly ICT based start – ups in the USA, these programs seek to fund new technology based firms with a presumption of high – growth or an aspiration towards it. - Current programs tend to treat new technology based firms as atomistic entities and often neglect their embeddedness in a network of co-founders and key personnel, customers and clients, investors and other public bodies.	- Empirical findings of this thesis show the existence of multiple innovation patterns; hence programs that aim to foster technology based entrepreneurship should include a portfolio of start – ups with different characteristics (e.g. firms with high – growth potential, niche product innovators, technology enablers, knowledge – intensive businesses etc.) instead of targeting entrepreneurs that fit a certain typological profile. Efficiency of policies that aim to foster technology based entrepreneurship may be increased by consolidating active direct funding programs and broadening their coverage. - Policy measures should go beyond financial incentives and seek to immense new technology based firms to collaborative networks. - Direct public funding for new technology based firms is justified by the systemic failure of allocating required resources to start – ups due to lack of financial institutions. Consequently, policy measures should aim to tackle this systemic failure. Therefore, the impact of direct funding programs should be carefully scrutinized and they should be ceased upon the removal of chronic distress.

Table 31 (continued)

Fostering diversity by variety creation	- As described in section 7.1, current innovation policy documents use high – level abstractions and tend to reduce innovation to a single dimension. Negligence of different knowledge generation mechanisms in addition to influx of external knowledge inhibits implementation of effective policy actions for increasing the resilience capacity of an innovation system.	- Factors that chronically impede innovation activities for firms with different characteristics should be identified and intervention should be intensified for those firms, which are ousted from the innovation system. - Research findings reported in this thesis show that diversity in sectors with low innovation intensity increases with higher collaborative activity in that sector. Consequently, sectoral and regional clusters that enable diffusion of new knowledge among its members should be encouraged. - Intra – industry heterogeneity of innovative behavior is also positively correlated with the share of foreign affiliated firms within a sector, which indicates that influx of external knowledge contributes to variety generation mechanisms within a system. Consequently, policy actions that enable external knowledge flow by linking local firms to the innovation value chain of foreign affiliated firms should be taken.

CHAPTER 8

CONCLUSION

You now have learned enough to see
That cats are much like you and me…
…You've seen them both at work and games,
And learnt about their proper names,
Their habits and their habitat:
But how would you address a cat?
So first, your memory I'll jog,
And say: a cat is not a dog...

T.S. Eliot
Old Possum's Book of Practical Cats

8.1 Summary and Discussion of Findings

This thesis primarily aims to explore the sources of intra-industry heterogeneity of innovative behavior. Evolutionary economics and strategic management literature provide compelling arguments to explain the persistent differences among firms within the same line of business. Building upon the theoretical framework outlined in Chapter 2 and using the analytical techniques explained in Chapter 3 this thesis sets six research objectives. Main research findings pertaining to these six research objectives are outlined below:

Objective 1 – Classification of innovative firms: Analysis of heterogeneity requires understanding the differences among units under consideration. Phylogenetic classification is a commonly used technique in evolutionary biology. Assuming "genes" are analogous to "routines" in the socio-economic domain a taxonomy of innovative firms was constructed using latent class analysis techniques. Classification method suggested in the OECD Innovation Microdata Project was slightly modified, i.e. latent class analysis instead of k-means clustering was used to group innovative firms.

Analysis results show that there are mainly six types of innovative firms in Turkey. High Profile Innovators group is mainly composed of large firms with high innovation expenditure intensities. Firms in this group display a high likelihood to engage in multiple innovative activities. Technology Oriented Innovators group is dominated by middle-sized firms that have a high likelihood of conducting in-house R&D. On the other hand, firms in this group display a low tendency to perform organizational and marketing innovations. Market Oriented Innovators group is characterized by their high propensity for introducing marketing innovations and cooperating with other parties. Process Oriented Innovators group has the lowest share of sales related to new products; but they have a high likelihood of introducing process innovations. Moreover firms in this group have a high tendency for acquisition of advanced machinery and equipment. Low Profile Efficiency Seekers and Low Profile Product Innovators have low innovation expenditure intensities. Both groups are mainly populated by small and medium sized firms.

Latent class analysis results indicate existence of firms with different innovation characteristics. Classification of firms according to their innovative behavior was a major milestone in this thesis, since dispersion of innovative firms within sectors was used to construct a diversity index based on the adjusted Simpson index, which is often used in biodiversity studies.

Objective 2 – Exploration of innovation patterns: As outlined in Chapter 3, there is a growing literature on firm level patterns of innovation. Most of these studies use factor analysis in combination with k-means (or hierarchical) clustering techniques to discover latent profiles of innovation among firms. OECD

Innovation Microdata Project also follows this methodology. Factor analysis was also undertaken in this thesis for two purposes. First, conducting a factor analysis would allow for comparison with the findings of OECD Innovation Microdata Project. Second, obtained factor scores could be used for constructing a heterogeneity index based on dissimilarity of firms within a sector.

Factor analysis results indicate four patterns of innovation, which are labeled as “technology oriented product innovation”, “efficiency oriented innovation”, “market oriented product innovation”, and “imitation based innovation”. These patterns are comparable to those innovation modes reported by OECD. Emergence of similar innovation patterns in most of the OECD countries can be seen as a sign of increasing globalization in the business domain. It can be argued that firms develop similar strategies to cope with competitive pressure brought by foreign firms or partaking in global production networks. Prevalence of similar innovation patterns also indicates that intra-industry heterogeneity of innovative behavior is common in most of the OECD countries.

Objective 3 – Predictive analysis: Strategic management literature suggests that possession of critical resources, capabilities and competences leads firms in the same line of business to follow different paths. In order to empirically investigate this claim, a classification tree model was constructed.

Classification tree analysis results show that a firm’s resource base (i.e. its number of employees and innovation expenditure), knowledge base (market related knowledge and academic knowledge) and cooperation characteristics (cooperation with clients, competitors and suppliers and academic institutions) have a bearing on the innovative characteristics of firms. High Profile Innovators are characterized by their large size and high innovation expenditure; whereas small firms with low innovation expenditure are assigned to Low Profile Product Innovators and Low Profile Efficiency Seekers groups. Classification tree shows that Market Oriented Innovators cooperate with other actors in the market and benefit from their knowledge base. This finding verifies the speculation made about Market Oriented Innovators in sub-section 5.1.2.

Objective 4 – Quantification of intra-industry heterogeneity: Intra – industry heterogeneity was quantified by constructing two heterogeneity indices. HET6 is based on the adjusted Simpson index and it is calculated using the dispersion of innovation groups within industries. HETEUC is the average Euclidean distance between firms nested in a sector based on their dissimilarity of innovation patterns. Obtained results indicate that all sectors embody diversity of innovative behavior to a certain extent. Sources of such heterogeneity were analyzed in the next step.

Objective 5 – Determinants of intra – industry heterogeneity: Sources of intra – industry heterogeneity of innovative behavior were analyzed in two stages. In the first stage, regression tree models were constructed to identify the factors that have a bearing on intra – industry heterogeneity. Regression tree results indicate that variables that are related to variety generation within a sector increase heterogeneity. On the other hand, increasing average firm size or concentration of firms that belong to a group reduces the amount of heterogeneity in that sector. Regression tree analysis for both HET6 and HETEUC show that a higher concentration of foreign firms contributes to heterogeneity. Foreign firms may have very different innovation practices when compared to their local counterparts; thus an increase in the concentration of foreign firms may elevate heterogeneity. Competitive pressure brought by foreign firms may also force local firms to seek and adopt new business methods thereby increasing intra-industry heterogeneity.

In the next stage, fixed effects time series models were estimated. Results obtained from these estimations are in-line with the regression tree analysis findings. An inverted u-shaped relationship between foreign ownership and HETEUC was found. This finding suggests that concentration of foreign firms increases intra-industry heterogeneity up to a certain extent. A number of arguments can be put forward to interpret this finding. Foreign firms may also exert competitive pressure local firms, forcing them to seek and adopt new business methods, however this competitive pressure may also eliminate local firms and reduce intra-industry heterogeneity. Alternatively local firms in the supply chain of foreign firms may adopt their innovation practices, either by knowledge spillover or by contractual enforcements. This alignment of innovation practices may also reduce intra-industry heterogeneity.

These findings conform to the evolutionary framework outlined in Chapter 2. Evolutionary economics provides a rich literature on simulation and modelling studies, which are constructed to test evolutionary hypothesis. However, verification of evolutionary concepts with empirical analysis is not frequently encountered in this strand of research. Findings from this thesis show that a theoretical framework, founded on the evolutionary premise by using biological analogies, can be supported by empirical analysis.

Objective 6 – Effects of intra-industry heterogeneity on innovation process: A modified version of the CDM model, as proposed in the OECD Innovation Microdata Project was estimated to investigate the effects of intra – industry heterogeneity on the innovation process.

Analysis results indicate that both HET6 and HETEUC are positively associated with innovation expenditure intensity and sales due to product innovations. Therefore, it can be argued that firms operating in more diverse sectors (in terms of innovative behavior) spend more on innovation and introduce product innovations more efficiently. No significant effect of HET6 is observed on labor productivity. On the other hand, estimation results show that HETEUC has a positive impact on labor productivity. On the overall, estimation results indicate that intra – industry heterogeneity is effective on the innovation process.

Consequently, research findings from this thesis show that:

- There are groups of firms within the same sector that display different innovation characteristics
- Firms follow different strategies in their operations; yet some regularities emerge in their innovative activities
- Patterns of innovation observed in Turkey and other OECD countries are compatible, suggesting there is an impact of globalization and international production networks on the innovation process
- As suggested in the strategic management literature, a firm's resource and knowledge base and its embeddedness in a network influence its innovative behavior
- Some degree of intra – industry heterogeneity exists in all sectors
- Variety generation contributes to heterogeneity, whereas selection mechanisms tend to reduce it
- Intra – industry heterogeneity effects the amount of innovation related expenditure and labor productivity within sectors

Building upon these research findings, following policy recommendations are put forward to ensure long – term sustainability of innovation system in Turkey:

- Innovation policies at any level should be built on comprehensive analysis of drivers, enablers and barriers to innovation and should identify the needs and requirements of various actors within that system.
- Innovation policies should aim to resolve systemic failures, which may lead to chronic distress or overall failure of the system; whereas perturbations that can be tolerated without further intervention should be closely monitored and utilized as guiding signals for transformation and adaptation to altering conditions.

- Risk assessment against path dependency and lock-in due to dependence on a singular solution should be an integral part of the innovation policy making process.
- Support programs that aim to foster technology based entrepreneurship should include a portfolio of start – ups with different characteristics instead of targeting entrepreneurs that fit a certain typological profile.
- R&D support programs should be diversified to match the specific needs of firms with different characteristics. Factors that chronically impede innovation activities for firms with different characteristics should be identified and intervention should be intensified for those firms, which are ousted from the innovation system.
- Sectoral and regional clusters that enable diffusion of new knowledge among its members should be encouraged to boost variety creation.
- Specific policy actions that enable external knowledge flow by linking local firms to the innovation value chain of foreign affiliated firms should be taken.

8.2 Research Limitations and Directions for Further Research

At the beginning of this thesis research, all four Innovation Survey data sets were made available by Turkish Statistical Institute. However Innovation Survey with reference year 2010 (IS2010) could not be utilized since firms were grouped according to NACE Rev.2, whereas NACE Rev 1.1 was used in other innovation surveys. Therefore, it was not possible to construct a larger database covering a longer time span.

Six different groups of innovative firms were identified and their innovative characteristics were described according to the data available in the data set. This description is incomplete since it does not provide any insight on their specific relations (with each other and other institutions) or network structure. Learning mechanisms, micro rules and routines of these firms should also be analyzed to complete the picture. Qualitative surveys and case studies can complement the findings of this thesis.

Due to limitations in the data set, two distinct heterogeneity measures were constructed and analyzed in this thesis. As outlined in Chapter 3, there are several metrics, which can be used to analyze intra – industry heterogeneity of innovative behavior. Future studies on this topic should also focus on the disparity aspect of diversity and use multiple measures to check their robustness.

Innovation – productivity linkage is analyzed with a simple model to allow for comparison between different countries. Capital expenditure and human capital effects could not be examined; hence there is a risk of overestimating the effect of product innovation on labor productivity. Innovation survey data alone is not sufficient to conduct analysis on the innovation – productivity linkage and it should be merged with other data sets. Many studies use sales per employee as a productivity indicator. However sales due to new products is the dependent variable in the knowledge production equation. Moreover innovative sales per employee is instrumented in the production function equation; hence sales value appears on both sides of the equation. Therefore, output or value added per employee can be better productivity indicators.

REFERENCES

Acs, Z. J., & Audretsch, D. B. (1990). *Innovation and small firms.* Cambridge Massachusetts: MIT Press.

Adams, R. (2003). *Perceptions of innovations: exploring and developing innovation classification - PhD Thesis.* Cranfield University School of Management.

Aldrich, H. E., & Ruef, M. (2006). *Organizations evolving.* London: Sage Publications.

Aldrich, H. E., Hodgson, G. M., Hull, D. L., Knudsen, T., Mokyr, J., & Vanberg, V. J. (2008). In defence of generalized Darwinism. *Journal of Evolutionary Economics, 18*, 577-596.

Ambec, S., & Barla, P. (2002). A theoretical foundation of the Porter hypothesis. *Economic Letters, 75*, 355-360.

Amit, R., & Shoemaker, P. J. (1993). Strategic assets and organizational rent. *Stratetic Management Journal, 14*, 33-46.

Andersen, E. S. (2004). Population thinking, Price's equation and the analysis of economic evolution. *Evolutionary and Institutional Economic Review, 1*(1), 127-148.

Archibugi, D. (2001). Pavitt's taxonomy sixteen years on: A review article. *Economics of Innovation and New Technology, 10*, 415-425.

Archibugi, D., Cesaratto, S., & Sirilli, G. (1991). Sources of innovative activities and industrial organization. *Research Policy, 20*, 357-368.

Arvanitis, S., & Hollenstein, H. (1997). Innovative activity and firm characteristics - a cluster analysis with firm-level data of Swiss manufacturing. *25th Annual Conference of the European Association for Research in Industrial Economics.* Copenhagen.

Audretsch, D. (1997). Technological regimes, industrial demography and the evolution of industrial structures. *Industrial and Corporate Change, 6*, 49-82.

Audretsch, D. B., & Mahmood, T. (1994). Firm selection and industry evolution: The post-entry performance of new firms. *Journal of Evolutionary Economics, 4*, 243-260.

Bailey, D. (1994). *Typologies and taxonomies. An introduction to classification techniques.* Thousand Oaks: Sage.

Baldwin, J., & Lin, Z. (2002). Impediments to advanced technology adoption for Canadian manufacturers. *Research Policy, 31*, 1-18.

Ballot, G., & Taymaz, E. (1999). Technological change, learning and macro-economic coordination: an evolutionary model. *Journal of Artificial Societies and Social Simulation, 2*(2).

Barney, J. B. (1986). Organisational culture: Can it be a source of sustained competitive advantage? *Academy of Management Review, 11*, 656-665.

Barney, J. B. (1986). Strategic factor markets: Expectations, luck, and business strategy. *Management Science, 32*, 1231-1241.

Barney, J. B. (1989). Asset stocks and sustained competitive advantage: A comment. *Management Science, 35*, 1511-1513.

Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*, 99-120.

Barney, J. B., & Clark, D. N. (2007). *Resource-based theory. Creating and sustaining competitive advantage.* Oxford University Presss.

Bartelsman, E., & Doms, M. (2000). Understanding productivity: Lessons from longitudinal microdata. *Journal of Economic Literature, 38*(3), 569-594.

Bartelsman, E., Scarpetta, S., & Schivardi, F. (2005). Comparative analysis of firm demographics and survival: Evidence from micro-level sources in OECD countries. *Industrial and Corporate Change, 14*(3), 365-391.

Battisti, G., & Stoneman, P. (2010). How innovative are UK firms? Evidence from the fourth UK community innovation survey on synergies between technological and organizational innovations. *British Journal of Management, 21*, 187-206.

Becker, M. C. (2004). The concept of routines twenty years after Nelson and Winter (1982): A review of the literature. *Industrial and Corporate Change, 13*, 643-677.

Bellone, F., Musso, P., Nesta, L., & Quéré, M. (2008). Market selection along the firm life cycle. *Industrial and Corporate Change, 17*(4), 753-777.

Benavante, J. M. (2006). The role of research and innovation in promoting productivity in Chile. *Economics of Innovation and New Technology, 15*(4/5), 301-315.

Blackler, F. (1995). Knowledge, knowledge work and organisations: an overview and interpretation. *Organisation Studies, 16*, 1021-1046.

Blundell, R., Griffith, R., & Van Reenen, J. (1999). Market share, market value and innovation in a panel of British manufacturing firms. *Review of Economic Studies, 66*(3), 529-554.

Boschma, R. A. (2005). Proximity and innovation: A critical assessment. *Regional Studies, 39*, 61-74.

Breiman, L., Friedman, J. H., Olshen, R. A., & Stone, C. J. (1984). *Classification and regression trees.* Boca Raton: Chapman and Hall.

Breschi, S., Malerba, F., & Orsenigo, L. (2000). Technological regimes and Schumpeterian patterns of innovation. *Economic Journal, 10*, 388-410.

Brown, J. S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organisation Science, 12*, 198 - 213.

Cameron, A. C., & Trivedi, P. K. (2009). *Microeconometrics using Stata.* College Station Texas: Stata Press Publication.

Castellacci, F. (2008). Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation. *Research Policy, 39*, 1139-1158.

Castellacci, F. (2010). How does competition affect the relationship between innovation and productivity? Estimation of a CDM model for Norway. *Economics of Innovation and New Technology, 20*(7), 637-658.

Cesaratto, S., & Mangano, S. (1993). Technological profiles and economic performance in the Italian manufacturing sector. *Economics of Innovation and New Technology, 2*, 237-256.

Chiraromonte, F., & Dosi, G. (1993). Heterogeneity, change and macroeconomic dynamics. *Structural Change and Economic Dynamics, 4*, 39-63.

Chudnovsky, D., Lopez, A., & Pupato, G. (2006). Innovation and productivity in developing countries: A study of Argentine manufacturing Firms' behavior (1992 – 2001). *Research Policy, 35*(2), 266-288.

Clark, N., & Juma, C. (1988). Evolutionary theories in economic thought. In G. Dosi, C. Freeman, R. Nelson, G. Silverberg, & L. Soete (Eds.), *Technical Change and Economic Theory* (pp. 197-218). London: Pinter Publishers.

Cohen, W. M., & Klepper, S. (1992). The tradeoff between firm size and diversity in the pursuit of technological progress. *Small Business Economics, 4*, 1-14.

Cohen, W. M., & Klepper, S. (1996). A reprise of size and R&D. *The Economic Journal, 106*(437), 925-951.

Cohen, W. M., & Levin, R. (1989). Empirical studies of innovation and market structure. In R. Schmalensee, & R. D. Willig, *Handbook of Industrial Organization* (Vol. 2, pp. 1059-1107). North Holland.

Cohen, W. M., & Malerba, F. (2001). Is the tendency to variation a chief cause of progress? *Industrial and Corporate Change, 10*, 587-608.

Cohen, W. M., Levin, R., & Mowery, D. (1987). Firm size and R&D intensity: A re-examination. *Journal of Industrial Economics, 35*(4), 543-565.

Cohendet, P., LLerena, P., & Sorge, A. (1992). Technological diversity and coherence in Europe : An analytical overview. *Revue d'économie Industrielle, 59*, 9-26.

Connor, K. R., & Prahalad, C. K. (1996). A resource-based theory of the firm. Knowledge versus opportunism. *Organisation Science, 7*, 477-501.

Cook, S. D., & Brown, J. S. (1999). Bridging epistemologies: The generative dance between organisational knowledge and organisational knowing. *Organisation Science, 10*, 381-400.

Crépon, B. E., Duguet, E., & Mairesse, J. (1998). Research innovation and productivity: An econometric analysis at the firm level. *Economics of Innovation and New Technology, 7*(2), 115-158.

Criscuolo, C. (2010). Innovation and productivity: Estimating the core model across 18 countries. In *Innovation in firms: a microeconomic perspective* (pp. 111-138). Paris: OECD.

Cronshaw, M., Davis, E., & Kay, J. (1994). On being stuck in the middle or good food costs less at Sainsbury's. *British Journal of Management, 5*, 19-32.

Dahlman, C. J., Routti, J., & Ylä-Anttila, P. (2006). *Finland as a knowledge economy : Elements of success and lessons learned.* Washington DC: World Bank.

Das, T. K., & Teng, B. S. (2002). Alliance constellations: A social exchange perspective. *Academy of Management Review, 27*, 445-456.

de Jong, J. P., & Marsili, O. (2006). The fruit flies of innovations: A taxonomy of innovative small firms. *Research Policy, 35*, 213-229.

Decarolis, D. M., & Deeds, D. L. (1999). The impact of stocks and flows of organisational knowledge on firm performance: An empirical investigation of the biotechnology industry. *Strategic Management Journal, 20*, 953-968.

Demsetz, H. (1973). Industry structure, market rivalry, and public policy. *Journal of Law and Economics, 16*, 1-9.

D'este, P., Iammarino, M., & von Tunzelmann, N. (2007). *What hampers innovation? Evidence from the UK CIS4.* SPRU Electronic Working Paper Series (SEWPS), No. 168.

Dierickx, I., & Cool, K. (1989). Asset stock accumulation and sustainability of competitive advantage. *Management Science, 25*, 1504-1511.

Dosi, G. (1982). Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change. *Research Policy, 11*, 147-162.

Dosi, G. (2005). *Statistical regularities in the evolution of industries: A guide through some evidence and challenges for the theory.* LEM Working Paper Series 2005/17.

Dosi, G., & Nelson, R. R. (1994). An introduction to evolutionary theories in economics. *Journal of Evolutionary Economics, 4*(3), 153-172.

Dyer, J. H. (1996). Does governance matter? Keiretsu alliances and asset specificity as sources of Japanese competitive advantage. *Organisation Science, 7*, 649-666.

Dyer, J. H., & Nobeoka, K. (2000). Creating and managing a high-performance knowledge sharing network: The Toyota case. *Strategic Management Journal, 21*, 345-367.

Dyer, J. H., & Singh, H. (1998). The relational view: Cooperative strategy and sources of interorganisational competitive advantage. *Academy of Managemet Review, 23*, 660-679.

Eisenhardt, K. M., & Santos, F. M. (2002). Knowledge based view: A new theory of strategy. In A. Pettigrew, H. Thomas, & R. Whittington (Eds.), *Handbook of Strategy & Management* (pp. 139-164). London: Sage.

Endler, J. A., & McLellan, T. (1988). The process of evolution: towards a new synthesis. *Annual Review of Ecological Systematics, 19*, 395-421.

Etzkowitz, H., & Leydesdorrf, L. (2000). The dynamics of innovation: from National Systems and “Mode 2” to a Triple Helix of university–industry–government relations. *Research Policy, 9*(2), 109-123.

European Commission. (2010). *Europe 2020 Flagship Initiative Innovation Union.* Brussels: European Commission.

European Commission. (2013). *Research and innovation performance in EU member states and associated countries .* Luxembourg: European Commision.

EUROSTAT. (2008). *NACE Rev.2 Statistical classification of economic activities in the European Communities.*

Evangelista, R. (2000). Sectoral patterns of technological change in services. *Economics of Innovation and New Technology, 9*, 183-221.

Feldman, M. P., & Audretsch, D. B. (1999). Innovation in cities: Science based diversity, specialization and localized competition. *European Economic Review, 43*, 409-429.

Flanagan, K., Uyarra, E., & Laranja, M. (2011). Reconceptualising the 'policy mix' for innovation. *Research Policy, 40*, 702-713.

Foss, K., & Foss, N. (1998). *The knowledge based-approach: An organizational economics perspective.* Copenhagen: Copenhagen Business School.

Foss, N. J. (1996). Knowledge based approaches to the theory of the firm: Some critical comments. *Organisation Science*, 470-476.

Foster, J. (2000). Competitive selection, self-organisation and Joseph A. Schumpeter. *Journal of Evolutionary Economics, 10*, 311-328.

Foster, J., & Metcalfe, S. (2001). *Frontiers of evolutionary economics: Competition, self organization and innovation policy.* Cheltenham: Edward Elgar.

Frenz, M., & Lambert, R. (2010). Exploring non-technological and mixed modes of innovation. In *Innovation in firms: a microeconomic perspective* (pp. 69-110). Paris: OECD.

Friedman, M. (1953). *Essays in positive economics.* Chicago: University of Chicago Press.

Fritsch, M., & Andreas, S. (2004). *The distribution and heterogeneity of technical efficiency within industries: An empirical assessment.* Freiberg Working Papers 2004-12.

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy, 33*(6-7), 897–920.

Geroski, P. A. (1989). Entry, innovation and productivity growth. *The Review of Economics and Statistics, 71*(4), 572-578.

Godfrey-Smith, P. (2000). The replicator in retrospect. *Biology and Philosophy, 15*, 403-423.

Godin, B. (2002). The rise of innovation survey: Measuring a fuzzy concept. *(Working Paper No:13)*. Canadian Science and Innovation Indicators Consortium.

Godin, B. (2003). The emergence of S&T indicators: Why did governments supplement statistics with indicators? *Research Poicy, 32*, 679-691.

Godin, B. (2004). The obsession for competitiveness and its impact on statistics: The construction of high-technology indicators. *Research Policy, 33*, 1217-1229.

Goodman, N. (1983). *Fact, fiction, and forecast* (4 ed.). Cambridge, Massachusetts: Harvard University Press.

Grant, R. M. (1991). The resource-based theory of competitive advantage: Implications for strategy formulation. *California Management Review, 33*, 114-135.

Grant, R. M. (1996). Towards a knowledge-based theory of the firm. *Strategic Management Journal, 17*, 109-122.

Greene, W. H. (2008). *Econometric analysis.* Upper Saddle River, New Jersey: Pearson Prentice Hall.

Greunz, L. (2003). The impact of industrial specialization and diversity on innovation. *Brussels Economic Review, 46*, 11-36.

Griffith, R., Huergo, E., Mairesse, J., & Peters, B. (2006). Innovation and productivity across four European countries. *Oxford Review of Economic Policy, 22*(4), 483-498.

Griliches, Z. (1986). Productivity, R&D and basic research at the firm Level in the 1970's. *American Economic Review, 76*(1), 141-154.

Griliches, Z. (1995). R&D and productivity: Econometric results and measurement issues. In P. Stoneman, *Handbook of the Economics of Innovation and Technological Change* (pp. 52-89). Oxford.

Griliches, Z. (1998). *R&D and productivity: The econometric evidence.* Chicago: University Of Chicago Press.

Grilliches, Z., & Mairesse, J. (1995). *Production functions: The search for identification (NBER Working Paper Series No:5067).* Cambridge, Massachusetts: National Bureau of Economic Research.

Gulati, R. (1998). Alliances and networks. *Strategic Management Journal, 19*, 293-317.

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic networks. *Strategic Management Journal, 21*, 203-215.

Hagedoorn, J., & Cloodt, M. (2003). Measuring innovative performance: Is there an advantage in using multiple indicators? *Reseach Policy, 32*, 1365-1379.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis.* New Jersey: Prentice Hall.

Hall, B. H., & Mairesse, J. (1995). Exploring the relationship between R&D and productivity in French manufacturing firms. *Journal of Econometrics, 63*(1), 263-293.

Hall, B. H., & Ziedonis, R. H. (2001). The patent paradox revisited: An empirical study of patenting in the U.S. semiconductor industry, 1979-1995. *RAND Journal of Economics, 32*(1), 101-12.

Hall, B. H., Lotti, F., & Mairesse, J. (2009). Innovation and productivity in SME's: Empirical evidence for Italy. *Small Business Economics, 33*(1), 13-33.

Hall, B. H., Mairesse, J., & Mohnen, P. (2009). *Measuring the returns to R&D.* NBER Working Paper Series.

Hamel, G. (1991). Competition for competence and interpartner learning within international strategic alliances. *Strategic Management Journal, 12*, 83-104.

Hansen, G. S., & Wernerfelt, B. (1989). Determinants of firm performance: The relative importance of economic and organizational factors. *Strategic Management Journal, 10*, 399-411.

Harrison, D. A., & Klein, K. J. (2007). What's the difference? Diversity constructs as separation, variety, or disparity in organizations. *Academy of Management Journal, 32*, 1199-1228.

Heckman, J. J. (1979). Sample selection bias as a specification error. *Econometrica, 47*(1), 153-162.

Helfat, C. E., & Peteraf, M. A. (2003). The dynamic resource-based view. Capability lifecycles. *Strategic Management Journal, 24*, 997-1010.

Hodgson, G. M. (1998). On the evolution of Thorstein Veblen's evolutionary economics. *Cambridge Journal of Economics, 22*(4), 415-431.

Hodgson, G. M. (2002). Darwinism in economics: From analogy to ontology. *Journal of Evolutionary Economics, 12*(3), 259-281.

Hodgson, G. M. (2004). Darwinism, causality and the social sciences. *Journal of Economic Methodology, 11*(2), 175-194.

Hodgson, G. M. (2005). Decomposition and growth: Biological metaphors in economics from the 1880s to the 1980s. In K. Dopfer (Ed.), *The Evolutionary Foundations of Economics* (pp. 105-139). Cambridge: Cambridge University Press.

Hodgson, G. M. (2006). *Economics in the shadows of Darwin and Marx.* Cheltenham: Edward Elgar Publishing.

Hodgson, G. M. (2007). Evolutionary and institutional economics as the new mainstream? *Evolutionary, Institutional Economics Review, 4*(1), 7-25.

Hodgson, G. M. (2008). The concept of a routine. In M. Becker (Ed.), *Handbook of Organizational Routines* (pp. 15-28). Cheltenham: Edward elgar Publishing.

Hodgson, G. M., & Knudsen, T. (2006). Why we need a generalized Darwinism, and why generalized Darwinism is not enough. *Journal of Economic Behavior and Organization, 61*, 1-19.

Holbrook, D., Cohen, W. M., Hounshell, D. A., & Slepper, S. (2000). The nature, sources and consequences of firm differences in the early history of the semiconductor industry. *Strategic Management Journal, 21*, 1017-1041.

Hollenstein, H. (2003). Innovation modes in the Swiss service sector: A cluster analysis based on firm-level data. *Research Policy, 32*, 845-863.

Hoskisson, R., Hitt, M., Wan, W., & Yiu, D. (1999). Theory and research in strategic management: Swings of a pendulum. *Journal of Management, 25*, 417-456.

Howlett, M., & Ramesh, M. (2003). *Studying public policy: Cycles and policy subsystems.* Oxford: Oxford University Press.

Huber, G. P. (1991). Organisational learning: The contributing processes and literatures. *Organisation Science, 2*, 88-115.

Iwai, K. (1984). Schumpeterian dynamics I and II. *Journal of Economic Behaviour and Organization, 5*, 321-351.

Jacobs, J. (1969). *The economy of cities.* New York: Random House.

Janz, N., Lööf, H., & Peters, B. (2003). *Firm level innovation and productivity - is there a common story across countries?* CESIS Electronic Working Paper Series Paper No:24.

Jefferson, G. H., Huamao, B., Xiaojing, G., & Xiaoyun, Y. (2006). R&D performance in Chinese industry. *Economics of Innovation and New Technology, 15*(4/5), 345-366.

Jensen, M. B., Johnson, B., Lorenz, E., & Lundvall, B. A. (2007). Forms of knowledge and modes of innovation. *Research Policy, 36*, 680-693.

Kahle, M. K., & Walkling, A. R. (1996). The impact of industry classifications on financial research. *Journal of Financial and Quantitative Analysis, 31*, 309-335.

Kalaycı, E. (2013). Foreigh ownership, R&D and knowledge spillovers in developing countries: Evidence from Turkey. *The International Journal of Social Sciences, 8*(1), 29-44.

Kale, P., Dyer, J. H., & Singh, H. (2002). Alliance capability, stock market response, and long term alliance success: The role of alliance function. *Strategic Management Journal, 23*, 747-767.

Kay, A. (2006). *The dynamics of public policy: Theory and evidence.* Cheltenham: Edward Elgar Publishing.

Kelly, M., & Hageman, A. (1999). Marshallian externalities on innovation. *Journal of Economic Growth, 4*, 39-54.

Khanna, T., & Yafeh, Y. (2007). Business groups in emerging markets: Paragons or parasites? *Journal of Economic Literature*, 331–372.

Kingdon, J. (1984). *Agendas, alternatives and public policies.* New York: Longham.

Klette, T. J., & Kortum, S. (2004). Innovating firms and aggregate innovation. *Journal of Political Economy, 112*(5), 986-1018.

Klevorick, A. K., Levin, R. C., Nelson, R. R., & Winter, S. G. (1995). On the sources and significance of inter-industry differences in technological opportunities. *Research Policy, 24*, 185-205.

Knell, M. (2008). Heterogeneity in economic thought: foundations and modern methods. In E. G. Carayannis, A. Kaloudis, & A. Mariussen (Eds.), *Diversity in the Knowledge Economy and Society* (pp. 35-54). Northampton, Massachussets, USA: Edward Elgar Publishing.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organisation Science, 3*, 383-397.

Kogut, B., & Zander, U. (1996). What firms do? Coordination, identity, and learning. *Organisation Science, 7*, 502-518.

Koka, B. R., & Prescott, J. (2001). Strategic alliances as social capital. *Strategic Management Journal, 22*, 795-816.

Kolenikov, S., & Angeles, G. (2004). *The use of discrete data in principal component analysis.* CPC/MEASURE Working paper No. WP-04-85.

Kovalenko, T., & Sornette, D. (2013). Dynamical diagnosis and solutions for resilient natural and social systems. *Planet@Risk, 1*(1), 7-33.

Kuperwasser, Y. (2007). *Lessons from Israel's intelligence reforms.* The Saban Center for Middle East Policy at the Brookings Institute Analysis Paper No:14.

Kwasnicki, W. (1996). Innovation regimes, entry and market structures. *Journal of Evolutionary Economics, 6*(4), 375-409.

Kwasnicki, W. (1998). Skewed distributions of firm sizes—an evolutionary perspective. *Structural Change and Economic Dynamics, 9*(1), 135-158.

Laranja, M., Uyarra, E., & Flanagan, K. (2008). Policies for science, technology and innovation: translating rationales into regional policies in a multi-level setting. *Research Policy, 37*(5), 823-835.

Leiponen, A., & Drejer, I. (2007). What exactly are technological regimes? Intra-Industry heterogeneity in the organisation of innovation activities. *Research Policy, 36*, 1221-1238.

Leiponen, A., & Helfat, C. E. (2010). Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal, 31*, 224-236.

Levinthal, D. A. (1997). Adaptation on rugged landscapes. *Management Science*, 934-950.

Levitt, B., & March, J. G. (1988). Organizational learning. *Annual Review of Sociology, 14*, 319-340.

Linzer, D. A., & Lewis, J. B. (2011). poLCA: an R package for polytomous variable latent class analysis. *Journal of Statistical Software, 42*(10), 1-29.

Lippman, S. A., & Rumelt, R. (1982). Uncertain imitability: An analysis of interfirm differences in efficiency under competition. *The Bell Journal of Economy, 13*, 418-438.

Loasby, B. J. (1999). *Knowledge, institutions and evolution in economics.* London: Routledge.

Lorenzoni, G., & Lipparini, A. (1999). The leveraging of ınterfirm relationships as a distinctive organisational capability: A longitudinal study. *Strategic Management Journal, 20*, 317-338.

Lööf, H., & Heshmati, A. (2006). On the relationship between innovation and performance: A sensitivity analysis. *Economics of Innovation and New Technology, 15*(4/5), 317-344.

Lööf, H., Heshmati, A., Asplund, R., & Naas, S. O. (2001). *Innovation and performance in manufacturing industries: a comparison of the nordic countries.* SSE/EFI Working Paper Series in Economics and Finance, No. 457.

Lui, S. S., Ngo, H., & Hon, A. H. (2006). Coercive stratetgy in interfirm cooperation: Mediating roles of interpersonal and interorganizational trust. *Journal of Business Research, 59*, 466-474.

Luo, X., & Deng, L. (2009). Do birds of a feather flock higher? The effects of partner similarity on innovation in strategic alliances in knowledge-intensive industries. *Journal of Management Studies, 46*(6), 1005-1030.

Magurran, A. E. (2004). *Measuring biological diversity.* Oxford: Blackwell Publishing.

Mahoney, J. T. (1992). The resource-based view within the conversation of strategic management. *Strategic Management Journal, 13*, 363-380.

Mairesse, J., & Mohnen, P. (2010). *Using innovation surveys for econometric analysis.* UNU-MERIT Working Paper Series.

Mairesse, J., & Sassenou, M. (1991). R&D and productivity: A survey of econometric studies at the firm level. *Science-Technology-Industry Review, 8*, 9-43.

Malerba, F. (1992). Learning by firms and incremental technical change. *Economic Journal, 102*, 845-859.

Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy, 31*(2), 247-264.

Malerba, F. (2005). Sectoral systems: How and why innovation differs across sectors. In J. Fagerberg, D. Mowery, & R. R. Nelson (Eds.), *Oxford Handbook of Innovation.* Oxford: Oxford University Press.

Malerba, F. (2007). Innovation and the dynamics and evolution of industries: Progress and challenges. *International Journal of Industrial Organization, 25*(4), 675–699.

Malerba, F., & Orsenigo, L. (1993). Technological regimes and firm behavior. *Indsutrial and Corporate Change, 2*, 45-71.

Malerba, F., & Orsenigo, L. (1995). Schumpeterian patterns of innovation. *Cambridge Journal of Economics, 19*, 47-65.

Malerba, F., & Orsenigo, L. (1996). The dynamics and evolution of industries. *Industrial and Corporate Change, 5*, 51-87.

March, J. G. (1981). Footnotes to organisational change. *Administrative Science Quarterly, 26*, 563-577.

Marsili, O., & Verspagen, B. (2002). Technology and the dynamics of industrial structure: An empirical mapping of Dutch manufacturing. *Indsutrial and Corporate Change, 11*, 791-815.

Masso, J., & Vahter, P. (2008). Technological innovation and productivity in late transition Estonia: Econometric evidence from innovation surveys. *The European Journal of Development Research, 20*(2), 240-261.

McGahan, A. (1999). The performance of U.S. corporations: 1981–1994. *Journal of Industrial Economics, 47*, 373-395.

McGahan, A., & Porter, M. E. (1997). How much does industry matter, really? *Strategic Management Journal, 18*, 15-30.

Metcalfe, J. S. (1994). Competition, Fisher's principle and increasing returns in the selection process. *Journal of Evolutionary Economics, 4*, 327-346.

Metcalfe, J. S. (1995). The economic foundations of technology policy: Equilibrium and evolutionary perspectives. In P. Stoneman (Ed.), *Handbook of the Economics of Innovation and Technical Change* (pp. 409-512). Cambridge, Massachusetts: Oxford University Press.

Metcalfe, J. S. (2005). Evolutionary concepts in relation to evolutionary economics. In K. Dopfer (Ed.), *The Evolutionary Foundations of Economics* (pp. 391-430). New York: Cambridge University Press.

Milligan, G. W. (1996). Clustering validation: Results and implications for applied analysis. In P. Arabie, L. J. Hubert, & G. de Soete (Eds.), *Classification and clustering* (pp. 341-375). River Edge: World Sceintific Publishing.

Ministry of Development. (2013). *Tenth development plan 2014 - 2018.* Retrieved December 2014, from http://www.kalkinma.gov.tr/Lists/Yaynlar/Attachments/518/Onuncu%20Kalk%C4%B1nma%20Plan%C4%B1.pdf

Montgomery, C. A., & Wernerfelt, B. (1988). Diversification, Ricardian rents, and Tobin's q. *The RAND Journal of Economics, 19*(4), 623-632.

Morlacchi, P., & Martin, B. R. (2009). Emerging challenges for science, technology and innovation policy research: A reflexive overview. *Research Policy, 38*(4), 571–582.

Moss, S. J. (1984). The history of the theory of the firm from Marshall to Robinson and Chamberlain: The source of positivism in economics. *Economica, 51*(203), 307-318.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Journal, 23*, 242-266.

Nelson, R. R. (1990). Capitalism as an engine of growth. *Research Policy, 19*, 193-214.

Nelson, R. R. (1991). Why firms differ and how does it matter? *Strategic Management Journal, 12*, 61-74.

Nelson, R. R. (1995). Recent evolutionary theorizing about economic change. *Journal of Economic Literature, 33*, 48-90.

Nelson, R. R. (2006). Evolutionary social science and universal Darwinism. *Journal of Evolutionary Economics, 16*, 491-510.

Nelson, R. R. (2007). Comment on: Dismantling Lamarckism: why descriptions of socio-economic evolution as Lamarckian are misleading, by Hodgson and Knudsen. *Journal of Evolutionary Economics, 17*, 349-352.

Nelson, R. R., & Winter, S. G. (1974). Neoclassical vs. evolutionary theories of economic growth: Criticism and prospectus. *Economic Journal, 84*, 886-905.

Nelson, R. R., & Winter, S. G. (1982). *An evolutionary theory of economic change.* Cambridge: Harvard University Press.

Nishimura, K. G., Nakajima, T., & Kiyota, K. (2005). Does the natural selection mechanism still work in severe recessions? Examination of the Japanese economy in the 1990s. *Journal of Economic Behavior and Organization, 58*, 53-79.

Nonaka, I. (1991). The knowledge creating company. *Harvard Business Review, 69*, 96-104.

Nonaka, I. (1994). A dynamic theory of organisational knowledge creation. *Organisation Science, 5*, 14-37.

Nonaka, I., & Konno, N. (1998). The concept of "Ba": Building a foundation for knowledge creation. *California Management Review, 40*, 40-54.

Nooteboom, B. (2009). *A cognitive theory of the firm: Learning, governance and dynamic capabilities.* London: Edward Elgar Publishing.

OECD. (1963). *Science, economic growth, and public policy.* Paris: OECD.

OECD. (2011). *ISIC Rev.3 technology intensity definition.* OECD Directorate for Science, Technology and Industry.

Oinas, P. (2005). Finland: A success story? *European Planning Studies, 13*(8), 1227-1244.

Opocher, A., & Steedman, I. (2008). The industry supply curve: two different traditions. *The European Journal of the History of Economic Thought, 15*(2), 247-274.

Paci, R., & Usai, S. (1999). Externalities, knowledge spillovers and the spatial distribution of innovation. *Geojournal, 49*, 381-390.

Pakes, A., & Griliches, Z. (1984). Patents and R&D at the firm Level: A first look. In Z. Griliches (Ed.), *R&D, Patents, and Productivity* (pp. 55-71). Chicago: University of Chicago Press.

Pamukcu, T. (2003). Trade liberalization and innovation decisions of firms: Lessons from post-1980 Turkey. *World Development, 31*(8), 1443–1458.

Pavitt, K. (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy, 13*, 343-373.

Pavitt, K., Robson, M., & Towsend, J. (1987). The size distribution of innovating firms in the UK: 1945-1983. *Journal of Industrial Economics, 35*, 297-316.

Peneder, M. (2003). Industry classifications: Aim, scope and techniques. *Journal of Industry, Competition and Trade, 3*, 103-129.

Peneder, M. (2010). Technological regimes and the variety of innovation behaviour: Creating integrated taxonomies of firms and sectors. *Research Policy, 39*, 323-359.

Penrose, E. (1959). *The theory of the growth of the firm.* New York: John wiley and Sons.

Peteraf, M. A. (1993). The cornerstones of competitive advantage. A resource based view. *Strategic Management Journal, 14*, 179-191.

Peters, B. (2008). *Innovation and firm performance: An emprical investigation for German firms.* New York: Physica Verlag.

Peters, B. (2009). Persistence of innovation: Stylised facts and panel data evidence. *Journal of Technology Transfer, 34*(2), 226-243.

Pol, E., Carroll, P., & Robertson, P. L. (2002). A new typology for economic sectors with a view to policy implications. *Economics of Innovation and New Technology, 11*, 61-76.

Porter, M. E. (1979). How competitive forces shape strategy. *Harvard Business Review, March-April*, 137-156.

Porter, M. E. (1980). *Competitive strategy: Techniques for analyzing industries and competitors.* New York: Free Press.

Porter, M. E. (1985). *Competitive advantage: Creating and sustaining superior performance.* New York: Free Press.

Porter, M. E. (1990). *Competitive advantage of nations.* New York: Free Press.

Porter, M. E. (1991). Towards a dynamic theory of strategy. *Strategic Management Journal, 12*, 95-117.

Powell, T. C. (1996). How much does industry matter? An alternative empirical test. *Strategic Management Journal, 17*, 323-334.

Prahalad, C. K., & Bettis, R. A. (1986). The dominant logic: A new linkage between diversity and performance. *Strategic Management Journal*, 485-501.

Prahalad, C. K., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review, 68*, 79-91.

Raffo, J., Lhuillery, S., & Miotti, L. (2008). Northern and southern innovativity: A comparison across European and Latin American countries. *The European Journal of Development Research, 20*(2), 219-239.

Rahmeyer, F. (2010). *A neo-Darwinian foundation of evolutionary economics: With an application to the theory of the firm.* Volkswirtschaftliche Diskussionsreihe // Institut für Volkswirtschaftslehre der Universität Augsburg 309.

Reinert, S. A. (2006). *Darwin and the body politic: Schaffle, Veblen, and the shift of biological metaphor in economics.* Working Papers in Technology Governance and Economic Dynamics No:8.

Richerson, P. J., Bettinger, R. L., & Boyd, R. (2005). Evolution on a restless planet: Were environmental variability and environmental change major drivers of human evolution? In F. M. Wuketits, & F. J. Ayala (Eds.), *Handbook of Evolution* (Vol. 2, pp. 223-242). Wiley.

Roark, E. (2004). Herbert Spencer's evolutionary individualism. *Quarterly Journal of Ideology, 27*(3&4), 1-31.

Romer, P. (1986). Increasing returns and long-run growth. *Journal of Political Economy, 22*(2), 141-153.

Romer, P. (1990). Endogenous technological change. *Journal of Political Economy, 94*(5), 1002-1037.

Rosenberg, N. (1996). Uncertainty and technological change. In R. Landau, T. Taylor, & G. Wright (Eds.), *The Mosaic of Economic Growth* (pp. 334-356). Stanford: Stanford University Press.

Rumelt, R. (1984). Towards a strategic theory of the firm. In B. Lamb (Ed.), *Competitive Strategic Management* (pp. 556-570). New Jersey: Prentice Hall.

Rumelt, R. (1991). How much does industry matter? *Strategic Management Journal, 12*, 167-185.

Safazynska, K., & van den Bergh, J. C. (2010). Evolutionary models in economics: A survey of methods and building blocks. *Journal of Evolutionary Economics, 20*, 329-373.

Sanchez, R. (2001). *Knowledge management and organizational competence.* Oxford: Oxford University Press.

Saviotti, P. P. (2001). Variety, growth and demand. *Journal of Evolutionary Economics, 11*, 119-142.

Saviotti, P. P., & Mani, G. S. (1995). Competition, variety and technological evolution: A replicator dynamics model. *Journal of Evolutionary Economics, 5*, 369-392.

Schmalensee, R. (1985). Do markets differ much? *American Economic Review, 75*, 341-351.

Schreyer, P., & Pilat, D. (2001). *Measuring productivity.* OECD Economic Studies No. 33.

Segarra-Blasco, A., Garcia-Quevedo, J., & Teruel-Carrizosa, M. (2008). Barriers to innovation and public policy in Catalonia. *International Entrepreneurship and Management Journal, 4*(4), 431-451.

Selye, H. (1973). The evolution of the stress concept. *American Scientist, 61*(6), 692-699.

Shapiro, C., & Varian, H. (1999). *Information rules. a strategic guide to the network economy.* Boston: Harvard University Press.

Shefer, F., & Frenkel, A. (1998). Local milieu and innovations: Some empirical results. *Annals of Regional Science, 32*, 185-200.

Sherman, H. J. (2003). Evolutionary economics from a radical perspective. *Journal of Economic Issues, 37*(1), 75-83.

Silverberg, G., Dosi, G., & Orsenigo, L. (1988). Innovation, diversity and diffusion: A self-organisation model. *The Economic Journal, 98*, 1032-1054.

Simon, H. A. (1991). Bounded rationality and organizational learning. *Organisation Science, 2*, 125-134.

Simonin, B. L. (1997). The importance of collaborative know-how: An empirical test of the learning organisation. *Academy of Management Journal, 40*, 1150-1174.

Simonin, B. L. (1999). Ambiguity and the process of knowledge transfer in strategic alliances. *Strategic Management Journal, 20*, 595-623.

Skinner, W. (1984). Operations technology: Blind spot in strategic management. *Interfaces, 14*, 116-125.

Slembeck, T. (1997). The formation of economic policy: a cognitive evolutionary approach to policy making. *Constitutional Political Economy, 8*(3), 225-254.

Som, O. (2012). *Innovation without R&D: Heterogeneous innovation patterns of non-R&D-performing firms in the German manufacturing industry.* Karlsruhe: Gabler Verlag.

Sotarauta, M., & Srinivas, S. (2006). Co-evolutionary policy processes: Understanding innovative economies and future resilience. *Futures, 38*(3), 312–336.

Soutaris, V. (2002). Technological trajectories as moderators of firm-level determinants of innovation. *Research Policy, 31*, 877-898.

Spender, J. C. (1996). Competitive advantage from tacit knowledge? Unpacking the concept and his strategic implications. In B. Moingeon, & A. Edmondson (Eds.), *Organisational Learning and Competitive Advantage* (pp. 56-73). London: Sage Publications.

Spender, J. C. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal, 17*, 45-62.

Spender, J. C., & Grant, R. M. (1996). Knowledge and the firm: Overview. *Strategic Management Journal, 17*, 5-9.

Srholec, M., & Verspagen, B. (2008). *The voyage of Beagle in innovation systems land. Explorations on sectors, innovation, heterogeneity and selection.* UNU-MERIT Working Paper Series No:8. Maastricht, The Netherlands: United Nations University.

Sterlacchini, A. (1989). R&D, innovations, and total factor productivity growth in British manufacturing. *Applied Economics, 21*(11), 1549-1562.

Stirling, A. (1998). *On the economics and analysis of diversity (SPRU Electronic Working Paper Series No:28).* Sussex: University of Sussex.

Stirling, A. (2011). Pluralising progress: From integrative transitions to transformative diversity. *Environmental Innovation and Societal Transitions, 1*(1), 82-88.

Stocking, G. W. (1962). Lamarckianism in American social science: 1890-1915. *Journal of the History of Ideas, 23*(2), 239-256.

Taleb, N. N. (2007). *The Black swan.* Penguin Books.

Tassey, G. (2000). Standardization in technology-based markets. *Research Policy, 29*, 587-602.

Taymaz, E. (2005). Are small firms really less productive. *Small Business Economics, 25*(5), 429-445.

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy, 15*, 285-305.

Teece, D. J. (2007). Explicating the dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal, 28*, 1319-1350.

Teece, D. J., & Pisano, G. (1994). The dynamic capabilities of firms: an introduction. *Industrial and Corporate Change, 3*, 537-556.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*, 509-533.

Tetlock, P. E., & Belkin, A. (1996). Counterfactual thought experiments. In P. E. Tetlock, & A. Belkin (Eds.), *Counterfactual Thought Experiments in World Politics: Logical, Methodological, and Psychological Perspectives* (pp. 1-38). Princeton, New Jersey: Princeton University Press.

Therneau, T. M., & Atkinson, E. J. (1997). *Introduction to recursive partitioning using the rpart routines.* Mayo Foundation.

Tidd, J., & Bessant, J. (2009). *Managing innovation: integrating technological, market and organizational change.* Chichester: Wiley.

Tratjenberg, M. (1990). A penny for your quotes: Patent citations and the value of innovations. *RAND Journal of Economics, 21*(1), 172-187.

Tsai, W. (2000). Social capital, strategic relatedness and the formation of ıntraorganisational linkages. *Strategic Management Journal, 21*, 925-939.

TÜBİTAK. (2010). *National Science, Technology and Innovation Strategy (2011-2016).* Retrieved December 2014, from http://www.tubitak.gov.tr/tubitak_content_files/BTYPD/strateji_belgeleri/UBTYS_2011-2016.pdf

TÜBİTAK. (2011). *Resolutions of 23rd Meeting of Supreme Council of Science and Technology.* Retrieved from http://www.tubitak.gov.tr/tubitak_content_files/BTYPD/BTYK/btyk23/BTYK_23_yeni_kararlar_toplu.pdf

United Nations. (2008). *International standard industrial classification of all economic activities (ISIC) Rev.4.* New York: United Nations.

van Belkum, A., Struelens, M., de Visser, A., Vergrugh, H., & Tibayrenc, M. (2001). Role of genomic typing in taxonomy, evolutionary genetics, and microbial epidemiology. *Clinical Microbiology Review, 14*(3), 547-560.

van der Panne, G., & van Beers, C. (2006). On the Marshall – Jacobs controversy: It takes two to tango. *Industrial and Corporate Change, 5*, 877-890.

Veblen, T. (1898). Why is economics not an evolutionary science? *Quarterly Journal of Economics, 12*(4), 373-397.

von Hippel, E. (1978). Successful industrial products from customer ideas. *Journal of Marketing, 1*, 39-49.

von Hippel, E. (1994). Sticky information and the locus of problem solving: Implications for innovation. *Management Science, 40*, 429-439.

Weitzman, M. L. (1992). On diversity. *The Quarterly Journal of Economics, 107*, 363-405.

Wernerfelt, B. (1984). A resource based view of the firm. *Strategic Management Journal, 5*, 171-180.

Wikipedia. (2014, December 23). *Decline of Detroit*. Retrieved from Wikipedia: http://en.wikipedia.org/wiki/Decline_of_Detroit

Winter, S. G. (1964). Economic 'natural' selection and the theory of the firm. *Yale Economic Essays, 4*, 225-272.

Winter, S. G. (1971). Satisficing, selection and the innovating remnant. *Quarterly Journal of Economics, 85*, 237-261.

Winter, S. G. (1984). Schumpeterian competition in alternative technological regimes. *Journal of Economic Behavior and Organization, 5*, 287-320.

Winter, S. G. (1987). Knowledge and competence as strategic assets. In D. J. Teece (Ed.). Cambridge: Ballinger.

Winter, S. G. (1988). On Coase, competence and the corporation. *Journal of Law, Economics and Organisation, 4*, 163-180.

Winter, S. G. (1990). Survival, selection, and inheritance in evolutionary theories of organisation. In J. V. Singh (Ed.), *Organisational Evolution - New Directions* (pp. 269-297). Newbury Park, CA: Sage.

Witt, U. (1996). A "Darwinian revolution" in economics? *Journal of Institutional and Theoretical Economics, 152*, 707-716.

Witt, U. (2008). What is specific about evolutionary economics? *Journal of Evolutionary Economics, 18*, 547-575.

Woerter, M. (2009). Industry diversity and its impact on the innovation performance of firms: An empirical analysis based on panel data (firm-level). *Journal of Evolutionary Economics, 19*, 675-700.

Yurtseven, A. E., & Tandoğan, V. S. (2012). Patterns of innovation and intra-industry heterogeneity in Turkey. *International Review of Applied Economics, 26*, 657-671.

Zaheer, A., McEvilvy, B., & Perrone, V. (1998). Does trust matter? Exploring the effects of interorganisational and interpersonal trust on performance. *Organisation Science, 9*, 141-159.

APPENDICES

APPENDIX A - OUTPUT BASED CLASSIFICATION OF INDUSTRIES

A.1 The International Standard Industrial Classification of All Economic Activities (ISIC)

Economic and Social Council of the United Nations adopted the first version of the International Standard for Classification of All Economic Activities (ISIC) in 1948 and recommended the member countries to either adopt this system as their national standard or rearrange their statistical data according to the ISIC for to enable international comparison. The United Nations, the International Labour Organization (ILO), the Food and Agriculture Organization (FAO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Industrial Development Organization (UNIDO) and other international bodies use the ISIC when publishing and analyzing statistical data (United Nations, 2008).

ISIC was first revised in 1958, followed by a second revision in 1968. Third revision of ISIC was issued in 1990. Third revision of ISIC enabled more detailed analysis of service sectors and compatibility with other activity based classifications. Third revision of ISIC was updated in 2002 in order to cover emerging economic activities, especially in the service sectors. Fourth revision of ISIC was issued in 2006 with the objectives of improving and strengthening its relevance and comparability with other classification systems, while sustaining continuity (United Nations, 2008).

ISIC covers the economic activities within the production boundary of the System of National Accounts (SNA). In this sense, economic activity carried out by an entity is related to the type of production it engages with. Moreover an industry is defined as the set of all production units engaged primarily in the same or similar kinds of productive economic activity. These economic activities are hierarchically subdivided into a four level structure of mutually exclusive groups. The categories at the highest level are called sections, which are alphabetically coded categories intended to facilitate economic analysis. The entire spectrum of economic activities is segmented into broader groups such as C – Manufacturing, or J - Information and Communication by these sections. The classification is then organized into successively more detailed categories, which are numerically coded: two-digit divisions; three-digit groups; and, at the greatest level of detail, four-digit classes (United Nations, 2008).

According to ISIC, a principle activity of an economic entity is defined as the activity that contributes most to the value added of the entity, or the activity the value added of which exceeds that of any other activity of the entity. On the other hand, a secondary activity is defined as the activity that produces products eventually for third parties and that is not a principal activity of the entity under scrutiny. Principal and secondary activities cannot be performed, unless they are supported by ancillary activities such as bookkeeping, maintenance, transportation, storage, sales and marketing. The output of an ancillary activity is consumed internally within the same economic entity; hence generally their records are not kept separately (United Nations, 2008).

Economic entities, which produce goods and services may have a variety of legal, accounting, organizational and operating structures. In order to attain consistency and international comparability in statistics, definition and delineation of statistical units, which are suitable for data gathering and aggregation, are required. The comparability of statistics is greatly enhanced when the units about which statistics are compiled are similarly defined and classified. In this sense, a statistical unit can be defined as an entity about which information is sought and about which statistics are ultimately compiled (United Nations, 2008).

Statistical units may be defined according to legal, accounting or organizational criteria; geographical criteria; and economic criteria. Grouping entities engaging in similar activities makes it easier to analyze goods and services produced in the economy using similar production technologies. In this sense, an institutional unit is defined as an economic entity that is capable, in its own right, of owning assets, incurring liabilities and engaging in economic activities and transactions with other entities. It may own and exchange goods and assets, is legally responsible for the economic transactions that it carries out and may enter into legal contracts. Institutional units include persons or groups of persons in the form of households and legal or social entities whose existence is recognized by law or society independently of the persons or other entities that may own or control them (United Nations, 2008).

An institutional unit in its capacity as a producer of goods and services is defined as an enterprise. An enterprise is an economic transactor with autonomy in respect of financial and investment decision-making, as well as authority and responsibility for allocating resources for the production of goods and services. It may perform one or more productive activities. On the other hand, establishment is defined as an enterprise or part of an enterprise that is situated in a single location and in which only a single (non-ancillary) productive activity is carried out or in which the principal productive activity accounts for most of the value added (United Nations, 2008).

There are other statistical unit definitions as well. A kind-of-activity unit is an enterprise or part of an enterprise that engages in only one kind of productive activity or in which the principal productive activity accounts for most of the value added. Compared with the establishment, in the case of such a unit, there is no restriction on the geographic area in which the activity is carried out but it is characterized by homogeneity of activity. Enterprises often engage in productive activity at more than one location, and for some purposes it may be useful to partition them accordingly. Thus, a local unit is defined as an enterprise or a part of an enterprise (for example, a workshop, factory, warehouse, office, mine or depot) which engages in productive activity at or from one location. The definition has only one dimension, in that it does not refer to the kind of activity that is carried out (United Nations, 2008).

Statistical units are classified according to the top-down method, which follows a hierarchical classification such that the classification of a unit at the lowest level of the classification must be consistent with the classification of the unit at the higher levels. Following steps are followed in order to satisfy this condition (United Nations, 2008):

1. Identify the section that has the highest share of the value added.
2. Within this section, identify the division that has the highest share of the value added
3. Within this division, identify the group that has the highest share of the valued added
4. Within this group, identify the class that has the highest share of value added

This procedure is articulated with the following example. Assume that a reporting statistical unit performs the activities shown in Table 30:

Table 32 Industry allocation scheme

Section	Division	Group	Class	% Value added
C	25	251	2512	7
	28	281	2816	8
		282	2821	3
			2822	21
			2824	8
	29	293	2930	5
G	46	461	4610	7
		465	4659	28
M	71	711	7110	13

First, corresponding section is determined. As can be seen in Table 2 section C constitutes 52% of value added, whereas activities belonging to section G and M create 35% and 13% of value added respectively. In the next step, corresponding division within section C is identified. 40% of value added is attributable to activities in division 28. Following the hierarchical procedure described above, 282 is identified as the corresponding group, since 32% of value added belongs to this group. Finally, corresponding class in group 282 is identified as 2822.

A.2 Statistical Classification of the Economic Activities in the European Community - NACE[17]

Origin of the NACE system can be traced back to Classification of Industries Established in the European Communities – NICE, which was developed in 1961 and covered extraction, energy-production and manufacturing industries in addition to the construction sector. Classification of Trade and Commerce in the European Communities –NCE was developed in 1965 with the purpose of

[17] Acronym is derived from the French title “Nomenclature générale des Activités économiques dans les Communautés Européennes”

covering all commercial activities in Europe. Broad categorizations for service and agriculture sectors were added to the NCE in 1967 (EUROSTAT, 2008).

NACE was developed in 1970, however this initial attempt to construct a classification covering all economic activities in Europe suffered from two major caveats. Collection of data was not enforced by means of a Community legislation, data gathered at the national level was transformed to the NACE format by means of conversion tables, which reduced data quality and comparability. Moreover, NACE rev.1970 was not integrated to internationally recognized frameworks, thus it offered poor comparability with other international classifications of economic activities (EUROSTAT, 2008).

EUROSTAT collaborated with the United Nations Statistical Office, in order to align NACE with other internationally recognized standards. NACE rev.1 was developed in line with ISIC rev.3 and it included details of activities that were common in Europe but inadequately represented in ISIC rev.3. NACE rev. 1 was established by Council Regulation No 3037/90 of 9 October 1990. A minor revision of NACE rev.1 was introduced in 2002, in order to include recently emerging economic activities such as call center operation to the classification system (EUROSTAT, 2008).

Efforts to upgrade NACE rev.1.1 to NACE rev.2 were launched in 2002. The Regulation establishing NACE Rev. 2 was adopted in 2006. NACE Rev. 2 is to be used, in general, for statistics referring to economic activities performed from 1 January 2008 onwards. Due to increasing efforts to integrate NACE with internationally recognized classification standards, NACE adopts the same terminology with ISIC to define economic activities and statistical units. Moreover, hierarchical classification procedure, which has been explained in detail for ISIC rev.4 also applies for NACE rev.2 (EUROSTAT, 2008).

APPENDIX B –CLUSTER ANALYSIS OVERVIEW

Various numerical analysis techniques with the common objective of identifying distinct groups that are homogeneous are generically termed as cluster analysis. Generally clusters are identified by the assessment of the relative distances between data points. Therefore, it is essential to select an appropriate similarity measure. Main strands of clustering methods include hierarchical clustering and k-means clustering. Cluster analysis is generally performed on continuous variables; hence scaling and outlier elimination are important issues.

B.1 Hierarchical Clustering

This method of clustering produces a hierarchical classification of data. In a hierarchical classification, the data is not divided into a particular number of classes of groups at a single step. On the contrary, a series of clusters that begin with a single cluster containing all entities to *n* clusters that contain each individual entity make up the classification. Agglomerative hierarchical clustering methods generate partitions by a series of successive fusions of the *n* individuals into groups. Once such fusions are made, they are irreversible. That is if two entities are allocated in the same group, they cannot appear in different groups in the subsequent steps.

An agglomerative hierarchical clustering procedure generates a series of partitions such as P_n, P_{n-1}, …, P_1. The first partition, P_n, consists of n single member clusters, and the last partition, P_1, is a single cluster containing all the entities. The fundamental procedure behind different agglomerative hierarchical clustering algorithms is summarized below:

(1) Form clusters C_1, C_2, …C_n each containing a single individual
(2) Find the nearest pair of distinct clusters (e.g. if C_i and C_j are the nearest clusters, then merge C_i and C_j and delete C_j)

(3) Check the number of remaining clusters. Continue until the number of clusters equals one.

A distance or similarity matrix should be calculated in order to initiate this procedure. Some of the similarity measures are listed in Table 33.

Table 33 Common similarity measures between entities a and b

Measure Name	Formula
Euclidean distance	$\sqrt{\sum_i (a_i - b_i)^2}$
Squared Euclidean distance	$\sum_i (a_i - b_i)^2$
Manhattan distance	$\sum_i \lvert a_i - b_i \rvert^2$
Maximum distance	$\max_i \lvert a_i - b_i \rvert$
Mahalanobis distance	$\sqrt{(a-b)^T S^{-1}(a-b)}$ *where s is the covariance matrix*
Cosine similarity	$\frac{a \cdot b}{\lVert a \rVert \lVert b \rVert}$

Once an inter-entity distance matrix is formed, the hierarchical clustering procedure described above can be initiated and at each stage individuals that are most similar are brought together by calculating the distance between an individual and the group and the distance between distinct groups. Distance calculation methods are summarized in Table 34:

Table 34 Common linkage methods used in hierarchical clustering

Measure Name	Formula
Single linkage	$\min\{d(a,b): a \in A, b \in B\}$
Complete linkage	$\max\{d(a,b): a \in A, b \in B\}$
Mean linkage	$\frac{1}{\lvert A\rvert \lvert B\rvert}\sum_{a\in A}\sum_{b\in B} d(a,b)$
Centroid linkage	$\lVert c_i - c_j \rVert$ where c_i and c_j are centroids of clusters I and j respectively

Dendogram is a two dimensional diagram, which depicts the synthesis performed at each stage of the hierarchical cluster analysis. A dendogram sample is shown in Figure 24. As can be seen in Figure 24, initially high number of clusters gradually decreases as proximate clusters are merged until all observations are grouped in a single cluster.

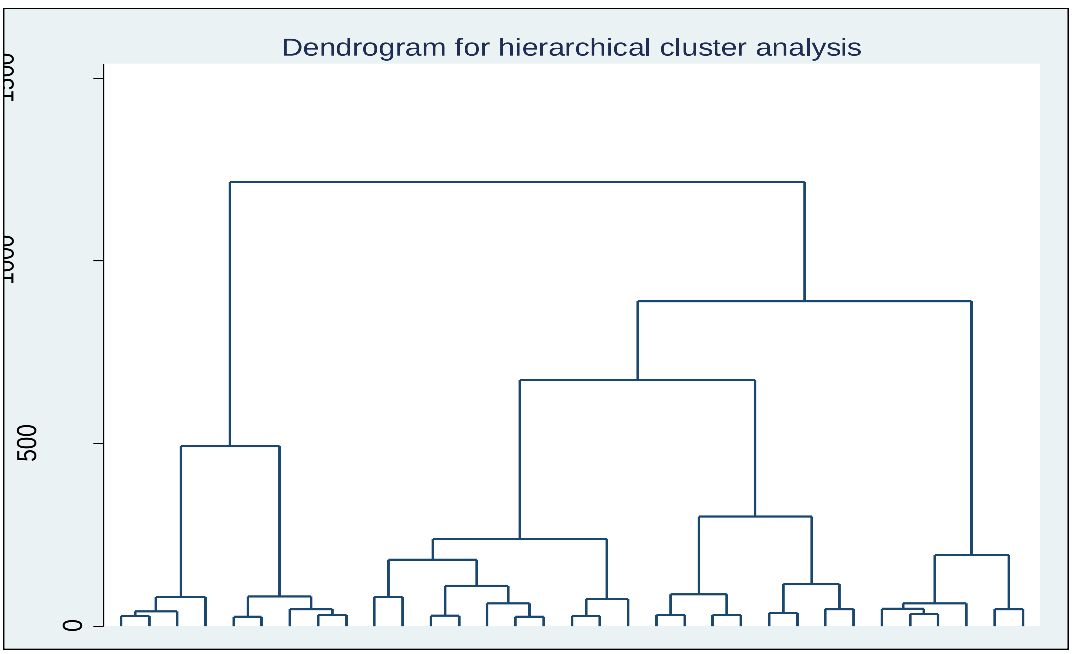


Figure 24 Sample dendogram for hierarchical cluster analysis

B.2 k-means Clustering

The k-means clustering method aims to divide the n entities in a multivariate data set into given k groups ($G_1, G_2, \ldots, G_k$) where G_i stands for the set of n_i individuals in the ith group, and k is given. Generally k-means clustering is implemented by assigning n entities to k groups so as to minimize the within group sum of squares over all variables. However it is not practical to examine every possible partition; hence various algorithms have been developed to seek for the minimum values of the clustering criterion (i.e. minimization of the within group sum of squares) by reorganizing existing partitions and keeping the new one only if it provides some improvement. Fundamental steps in such algorithms are outlined as follows:

(1) Find some initial partition of the individuals into the required number of groups

(2) Calculate the change in the clustering criterion produced by replacing each entity from its original cluster to another cluster

(3) Keep the change that brings the greatest improvement in the clustering criterion value

(4) Repeat (2) and (3) until no significant improvement can be attained

APPENDIX C – HAUSMAN TEST RESULTS

Hausman test can be instrumental in differentiating between fixed effects and random effects model in panel data analysis. In this method, null hypothesis suggests preferring random effects due to its higher efficiency. If the null hypothesis is rejected, fixed effects model is selected since it at least provides consistent results.

Hausman test was applied to the base models described in sub-section 5.3.3. As shown in Table 35, null hypothesis is rejected at $p<0.05$ level and fixed effects model is preferred.

Table 35 Hausman test results

Model	χ^2	p> χ^2
HET6 base (6 degrees of freedom)	13.36	0.014
HETEUC base (4 degrees of freedom)	8.92	0.025

APPENDIX D – SHARE OF INNOVATIVE FIRMS AND HETEROGENEITY

Entry and exit rates of firms are related to the variety generation and selection mechanisms within a sector. Therefore, a model with the change in the ratio of innovative firms in addition to sector level average of number of employees and innovation expenditure per employee as independent variables was separately estimated for HET6 and HETUC. Obtained results are shown in Table 36.

Table 36 Change in share of innovative firms and intra – industry heterogeneity

VARIABLES	HET6	HETEUC
Average firm size	-0.615***	0.249
	(0.104)	(6.093)
Innovation expenditure intensity	0.379***	4.957
	(0.0779)	(3.751)
% Change in number of innovative firms	0.0205**	1.189***
	(0.00945)	(0.422)
Year dummy (2006)	0.497***	10.63
	(0.179)	(8.528)
Constant	3.265***	13.25
	(0.830)	(42.18)
Observations	46	46
R-squared	0.649	0.247

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

As can be seen in Table 36, change in the share of innovative firms within a sector is positively associated with intra – industry heterogeneity. This finding suggests that new firm formation or change in the innovative behavior of existing firms contributes to the variety generation mechanism in that sector. However, these models were estimated using data from two years; hence analysis is lacking temporal depth. Therefore, additional research is necessary to verify the effects of firm entry – exit rates and changes in the innovative behavior of firms on intra – industry heterogeneity.

APPENDIX E – MARGINAL EFFECTS OF INTERACTION TERMS

Regression tree analysis results shown in sub – section 5.3.2 indicate that there is a possible interaction between sector level average firm size and share of foreign firms, in addition to share of firms that perform in – house R&D and share of foreign firms. Therefore, interaction terms between these variables were included in regression models that are presented in sub – section 5.3.3. However, interpretation of estimated coefficients for these interaction terms is not straightforward; hence marginal effects of these interaction terms were calculated as suggested by Greene (2008, pp. 112-114). Estimation results are presented in Table 37.

Table 37 Marginal effects for interaction terms

Change of	With respect to	at min.	at mean	at max.
Share of foreign firms	Sector level average firm size	-0.652 (1.429)	-0.662 (1.022)	-0.689 (7.739)
Sector level average firm size	Share of foreign firms	12.294 (35.990)	12.056 (18.046)	11.224 (118.275)
Share of foreign firms	Share of R&D performers	7.134 (7.839)	6.424 (10.174)	4.162 (29.89)
Share of R&D performers	Share of foreign firms	15.331 (55.990)	12.308 (18.704)	3.592 (98.217)

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

As can be seen in Table 37, the marginal effect of higher average firm size on sector level heterogeneity is decreased when the share of foreign firms within that sector is higher. Analysis results show that share of foreign firms and degree of innovative heterogeneity are positively associated. On the other hand, this effect is diminished when the average firm size within a sector is higher. Both the share of in – house R&D performers and foreign firms within a sector contribute to intra – industry heterogeneity. However, marginal effect estimations show that a higher level of one of these variables tends to inhibit the positive effect of the other.

APPENDIX F – CURRICULUM VITAE

Personal Information:

Name **:** Alp Eren Yurtseven

Birth date **:** April 5th 1979

Nationality **:** Turkish

Marital status **:** Married

Professional Experience

- Scientific and Technological Research Council of Turkey, Scientific Programs Expert, January 2015 – present
- Univo R&D Consultancy Ltd, Managing Partner, September 2013 – January 2015
- Turkcell Technology R&D Corporation, Senior Consultant, June 2011 – September 2013
- Scientific and Technological Research Council of Turkey, Scientific Programs Expert, March 2006 – June 2011
- Yurtsevenler Construction Materials Ltd, Managing Partner, July 2001 – March 2006

Education:

- BSc in civil engineering, Middle East Technical University, 1997 - 2001
- MSc in civil engineering, Middle East Technical University, 2001 – 2004

Publications:

Sahmaran, M., **Yurtseven, A.E.**, Yaman, I.O., 2005. Workability of hybrid fiber reinforced self compacting concrete. Building and Environment 40, 1672 - 1677

Yurtseven, A.E., Tokyay, M., Yaman, I.O., 2006. Mechanical properties of hybrid fiber reinforced concrete. Measuring, Monitoring and Modeling Concrete Properties, 207 – 214

Yurtseven, A.E., Oztop, M., 2007. A model for promoting technology based enterprises in Turkey. 2nd International Conference on Innovation, Technology and Knowledge Economics İzmir, Turkey, 25th-26th May

Yurtseven, A.E., Kara, O., Pamukcu, T., 2009. A study on R&D performance after trade liberalization: Evidence from Turkish manufacturing firms. 3rd International Conference on Innovation, Technology and Knowledge Economics Ankara, Turkey, 24th-26th June

Erden, Y., **Yurtseven, A.E.,** 2010. Establishment and development of academic spin – off firms: Evidence from Turkey. DRUID – DIME Academy Winter 2010 PhD Conference, Aalborg, Denmark, 21st – 23rd January

Tandogan, S., **Yurtseven, A.E**., 2010. Input additionality of R&D and innovation subsidies: Empirical evidence from community innovation survey in Turkey. The 8th GLOBELICS International Conference Making Innovation Work for Society: Linking, Leveraging and Learning, Kuala Lumpur, Malaysia, 1st - 3rd November

Yurtseven, A.E., Tandogan S., 2012. Patterns of innovation and intra-industry heterogeneity in Turkey. International Review of Applied Economics 26 (5), 657 – 671.

APPENDIX G – TURKISH SUMMARY

1. Giriş

Modern evrimsel biyolojinin temel taşları olan çeşitlilik, seçim ve koruma kavramları çağdaş evrimci iktisat yazınında da yaygın olarak kullanılmaktadır. Buna göre bir popülasyon değişken karakteristikleri olan seçim birimlerinden oluşmaktadır. Bu karakteristikler üzerinden işleyen seçim mekanizmaları sanal olarak bir uygunluk skoru oluşturur. Seçim birimlerinin bağıl önemleri bu uygunluk skoruna göre değişir.

Bu bağlamda ekonomik alanda belirli değişiklikleri seçen ya da kayıran bütün mekanizmaların evrimsel biyolojideki doğal seçim kavramına benzediği söylenebilir. Biyolojik benzetmeler kullanılarak, bir firmanın karlılığının seçim uygunluğu ile alakalı olduğu ve seçim sonucunda sadece karlı firmaların hayatta kalmasının homojen bir kar maksimizasyonu davranışına yol açacağı iddia edilebilir. Bu durumda seçim mekanizmasının çeşitliliği azalttığı ve firma hedeflerinin yakınsamasına neden olduğu varsayılabilir.

Diğer taraftan Dosi (2005) rekabet süreçlerine rağmen firmalar arasında sürekli bir çeşitlilik olduğunu bildirmektedir. Bu durumda çeşitliliğin doğal seçim için gerekli hammaddeyi sağladığı söylenebilir. Doğal seçim her zaman en iyi çözüme yol açmamaktadır. Ancak bu süreç çeşitliliği fazla bir ortamda gerçekleştiğinde daha iyi sonuçların elde edilmesi beklenebilir.

Benzer teknolojik yetkinlikler, finansal ödüller ve kısıtlar firmalar için ortak yollar şekillendirebilir. Nelson ve Winter'in (1982) ortaya koyduğu teknolojik rejim kavramında olduğu gibi bu kalıplar firmaların yenilik aktivitelerini benzer biçimde organize etmelerine neden olabilir.

Sektörel yenilik sistemi yaklaşımı bir sektör içinde yer alan firmaların, bilgi kaynakları ve teknolojileri paylaşmaları ve yenilik konusunda benzer istekleri olduğu için birbirine yakın davranış sergileyeceği fikrine dayanmaktadır (Malerba ve Orsenigo, 1996; Malerba 2005). Ancak karlılık açısından firmaların sergilediği farklı performansın sektörel değil firmaya özgü niteliklerden kaynaklandığını gösteren birçok sayısal çalışma bulunmaktadır (Rumelt, 1991; Powell; 1996).

Sektör içinde sürekli olarak farklı yenilik davranışları olacağından bu çeşitliliğin kaynakları ve yenilik performansı üzerindeki etkilerinin araştırılması gerekmektedir. Bu nedenlerle bu tez çalışması aşağıdaki araştırma sorularının cevaplanmasını amaçlamaktadır:

- Firmaların yenilikçi karakteristiklerine göre bir sınıflandırma oluşturmak mümkün müdür?
- Firmalar arasında ortak yenilik biçimleri var mıdır?
- Firmanın kaynak ve bilgi temeli yenilik karakteristiklerini nasıl etkilemektedir?
- Bir sektör içindeki yenilik davranışlarının çeşitliliğini nicel hale getirmek mümkün müdür?
- Sektör içindeki çeşitliliği etkileyen belirleyici etmenler nelerdir?
- Sektör içi çeşitlilik firmaların yenilik performansını nasıl etkilemektedir?

2. Teorik ve Uygulama Çerçevesi

Evrimci iktisadın kar maksimizasyonu ve denge durumlarına dair varsayımlara dayanan neo – klasik iktisat ekolüne karşı somut bir karşı tez geliştirdiği söylenebilir. Evrimci iktisatta incelenen elemanların (bireyler, işletmeler vb) karar alma süreçlerini optimize edemedikleri varsayılmaktadır. Bu nedenle kısıtlı şekilde rasyonel davranabilen ekonomik aktörler, eylemlerinde kendi geliştirdikleri kuralları ve yöntemleri kullanmaktadırlar. Bu pratik kurallar ya da rutinler değişebilen operasyon şartlarına uyum sağlanabilmesi için zamanla değişikliğe uğrayabilmektedir. Buna göre ekonomik aktörler yine de karlarını maksimize etmeye çalışmaktadırlar. Ancak eylemlerinin sonuçlarını bağlama ve ortam algılarına göre sadece tatmin edici ya da yetersiz olarak değerlendirebilmektedirler.

Toplam ekonomik performans farklılaşma ve seçim arasındaki etkileşimle ilişkilendirilmektedir. Oturmuş rutinlerden, stratejilerden, süreçlerden ya da problem çözme yöntemlerinden sapmalar sisteme sürekli olarak yenilik katmaktayken, seçim mekanizmaları değişen koşullara uyum sağlama potansiyeli düşük alternatifleri eleyerek bu değişkenliği azaltmaktadır.

Evrimci iktisadın dinamik bakış açısı, sektör içindeki yenilik davranışlarının çeşitliliğini açıklamak için yararlıdır. Zaman içerisinde değişen kriterlere göre farklı seviyelerde değişen şartlara ve seçim mekanizmalarına uyum için harcanılan çaba aynı sektör içinde yer alan firmaların çeşitliliğine yol açmaktadır. Ancak evrimci iktisat içerisindeki farklı akımlar ekonomik değişimle ilgili tutarlı bir teori oluşturacak biçimde yakınsamamıştır.

Geoffrey Hodgson gibi evrimci iktisat ekolünün önde gelen araştırmacıları evrensel Darwinizmin biyolojik prensiplerin diğer alanlara uygulanması olarak ele alınmaması gerektiğini belirtmektedirler. Ancak Darwin'e atfedilen evrimci görüşlerin en temel kanıtları genetik alanında olduğundan biyolojik prensipler üzerinden genellemeler yapılması kaçınılmaz olmaktadır. Diğer taraftan genelleme ve benzetme birbirinden farklı kavramlardır. Benzetmede bir alandaki olaylar ve süreçler başka bir alandaki benzer olay ya da süreçlerin analizi için referans alınmaktadır. Uyumsuzluk gösteren noktalar istisna olarak ele alınmaktadır. Örnek olarak genetikte farklılığın kaynağı olan mutasyon neredeyse tamamen "kör" bir süreçken insan iradesi teknolojik değişimde önemli bir rol oynamaktadır. Biyoloji alanında seçim mekanizmaları fenotipik karakteristikler üzerinde işleyerek gen havuzunda spesifik bir genin bağıl frekansını belirlemektedir. Darwinci seçim kavramının sosyoekonomik alanda genelleştirilmesi muğlak sonuçlara yol açabilmektedir. Biyolojideki evrim kavramında replikatör olan genler, etkileşim elemanı olan gen taşıyıcıların hayatta kalmasına bağımlıdır. Değişen koşullara uyum sağlayamayan etkileşim elemanları elenirler. Diğer taraftan ekonomik aktörler (bireyler, firmalar vb) sosyoekonomik alandan elenseler bile iş yapış biçimleri ve rutinleri ortadan kalkmamaktadır.

Biyolojik evrimde etkileşim elemanları yeni özellikler geliştirebilirler; ancak bu olay genlerin değişimi ile sonuçlanmaz. Diğer taraftan sosyoekonomik alandaki aktörler bir anlamda Lamark'ın evrim görüşündeki gibi kendi iradeleriyle rutinlerini değiştirebilir ve yeni yöntemler arayabilirler.

Biyoloji ve sosyoekonomik alanlardaki replikasyon mekanizmaları da farklılıklar göstermektedir. Hayatta kalan canlıların genleri yeni nesillere aynen kopyalanarak transfer edilmektedir. Replikasyon sürecindeki hatalar mutasyonlara sebep olmaktadır. Sosyoekonomik alanda replikasyon farklı seviyelerdeki bilgi ve diğer yetkinliklerin tekrarlanması ve taklit edilmesi ile sağlanmaktadır. Bu süreç çalışma, iletişim ve öğrenme yoluyla gerçekleşmektedir. Bu bilişsel süreçler seçilen kural ve rutinlerin başarı algısını belirleyen zihinsel modellere dönüştürülür. Sonuç olarak sosyoekonomik alandaki koruma ve aktarma mekanizması önemli ölçüde aktörlerin iradesine dayanmaktadır ve Lamark'ın evrim görüşlerine benzerlikler taşır. Bu tezde yapılan sınıflandırma çalışmalarının yorumlanmasında biyolojik evrim kavramları kullanılsa da bu yaklaşım evrensel Darwinizmi genelleme çabası olmaktan uzaktır. Bu tezdeki teorik çerçeve Richard Nelson (2006; 2007) tarafından öne sürülen neo Schumpeterci temaya daha yakındır.

Stratejik yönetim yazını altında özellikle kaynak temelli firma teorisi ve diğer yetkinlik temelli teoriler firma performansının büyük ölçüde uygulama alanı ve bağlama özgü kaynaklara, yetkinliklere ve yeteneklere bağlı olduğunu öne sürerek aynı iş kolundaki firmaların farklı performansının açıklanmasına önemli bir katkı sağlamaktadır. Stratejik yönetim yazını neo-klasik ekonomideki pasif firma görüşünü geliştirerek firmaları sadece dış etkilere tepki veren değil çevre koşulları etkileyebilen ve değiştirebilen aktif, operasyonel ve gelişen organizasyonlar olarak ele almaktadır. Bu yapıda firmalar sürekli yeni yetkinlikler geliştirerek rekabetçi ortamın getirdiği yeni koşullara uyum sağlayabilmektedir. Ancak stratejik yönetim yazını bu tez özelinde analitik bir çerçeve oluşturmak için gerekli bütün cevapları da sağlamamaktadır.

Porter'in çerçevesinde önerilen strateji piyasa koşullarıyla ilgili bilgilerin tam olmasını gerektirmektedir. Buna ilave olarak verilen dış koşullara göre optimal stratejinin uygulanması için karar vericilerin rasyonel davranış göstermesi gerekmektedir. Tüm bilgiye sahip olunması ve tamamen rasyonel seçimlerin yapılması durumunda sektör içindeki firmaların çok benzer davranışlar göstermesi gerekir. Bu durumda piyasa temelli stratejik yönetim görüşü yenilik davranışlarındaki farklılık ve sektör içi çeşitliliği açıklamamaktadır.

Diğer taraftan kaynak temelli firma teorisi de bütünlük içeren bir terminoloji sunamamaktadır. Kaynak temelli teoriye göre firmalar değerli kaynakları edinerek ve ilgili yetkinlikleri kazanarak rekabetçi bir konum elde edebilir. Ancak firmanın kaynak durumu rekabetçi konumu ile de yakından ilişkilidir. Ayrıca kaynak temelli teorideki bazı kavramların ampirik analizde kullanılması oldukça zordur. İş yapış biçimleri, rutinler, yetkinlikler, işbirliği ağındaki konum ya da dinamik yetenekler gibi maddi olmayan varlıkların nicel hale getirilmesi mümkün değildir. Bu tez kapsamında elde edilen yenilikçi firma sınıfları ve sınıf aidiyeti olasılıklarının yukarıda bahsedilen maddi olmayan varlıklarla ilişkili olduğu söylenebilir. Sınıf aidiyetinin belirleyici etmenlerinin analizinde kullanılan özyineli ayrıştırma yöntemi modelindeki açıklayıcı değişkenler stratejik yönetim yazını temel alınarak seçilmiştir.

Bir sektörde sergilenen ilerleme derecesinin o sektör içindeki ekonomik çeşitliliğe bağlı olduğu söylenebilir. Nelson (1990) bu tür bir çeşitliliğin önemini vurgular ve çeşitliliği sektörlerin evrimsel gelişiminin temeline oturtur. Nelson'a göre kapitalizmin merkezi planlamaya göre en önemli avantajı mevcut tekniklerin ilerletilebileceği geniş bir seçenek spektrumu sunmasıdır.

Stirling (1998) çeşitliliğin belirsizliğe karşı bir tür esneklik sağlayan bir yetenek havuzu olarak görülebileceğini iddia eder. Stirling'e göre (1998) esneklik, gürbüzlük, istikrar, modülerlik ve artıklık kavramları belirsizliğe karşı sistematik bir tepki olarak görülebilir. Ancak stratejilerin çeşitlendirilmesi, yüksek düzeyde belirsizlik ve bilinmezlikle baş etmek için öne çıkan en önemli politika aracıdır.

Saviotti (2001) çeşitliliği bir ekonomiyi betimlemek için gerekli aktör, eylen ve nesne sayısı olarak tanımlamakta ve çeşitlilikteki artışın uzun dönemli ekonomik büyüme için bir gereklilik olduğu ve çeşitlilik ve üretkenlik artışlarının ekonomik gelişimde birbirini tamamlayan unsurlar olduğu şeklinde iki hipotez öne sürmektedir.

Diğer taraftan çeşitlilikten kaynaklanan ek maliyetlerin de dikkate alınması gerekmektedir. Cohendet ve diğerlerine göre (1992) ekonomik eylemlerin çeşitliliğindeki üretim ve işlem maliyetlerinde artışa neden olabilir. Bunun aksine, standartlaşma önemli ölçüde maliyet avantajı sağlayabileceği gibi öğrenme, ağ dışsallığı ve esnekliği de beraberinde getirebilir. Bu tartışma Jacob ve Marshall – Arrow – Romer (MAR) dışsallıkları arasındaki farkları vurgulamaktadır. Jacob dışsallığı, bir bölgedeki yenilik ve büyümenin o bölgedeki sanayi kollarının çeşitliliği ile beslendiği fikrine dayanmaktadır. Diğer taraftan MAR dışsallığına göre bir sanayi kolunun bir bölgede yoğunlaşması bilgi taşmasına ve firmalar arasında bilgi alışverişine neden olmaktadır.

Bu tezde kullanılan teorik çerçeve evrimci iktisat ve kaynak temelli firma teorisi yazınından faydalanarak oluşturulmuştur. Buna göre firmanın yenilik stratejisi, kaynakların yanı sıra bilgi tabanı ve işbirliği ağları içindeki konum ile de ilişkilidir. Firmaların bu etmenlere göre farklı pozisyonlara sahip olması sektör içi çeşitliliğe neden olmaktadır. Diğer taraftan, sektör içindeki farklılaşım ve seçim mekanizmaları yenlik davranışlarındaki çeşitliliğin artmasına ya da azalmasına neden olmaktadır. Oluşturulan bu teorik çerçeveye uygun olarak altı araştırma amacı belirlenmiştir.

- Amaç 1 – Yenilik yapan firmaların sınıflandırılması
- Amaç 2 – Yenilik biçimlerinin belirlenmesi
- Amaç 3 – Firmanın kaynak durumu ve yenilik biçimleri arasındaki ilişkinin belirlenmesi
- Amaç 4 – Sektör içi çeşitliliğin nicel hale getirilmesi
- Amaç 5 – Sektör içi çeşitliliği etkileyen etmenlerin belirlenmesi
- Amaç 6 – Sektör içi çeşitliliğin firmaların yenilik süreçleri üzerindeki etkisinin belirlenmesi

Bu araştırma amaçları doğrultusunda bir uygulama çerçevesi oluşturulmuştur. Evrimci bir yaklaşımla firma bünyesindeki rutinlerin biyoloji alanındaki genlere benzediği varsayımı yapılmıştır. Firmaların yenilik alanındaki eylemleri zaman içinde süreklilik arz ettiği ve belirli örüntüler sergiledikleri için rutin olarak kabul edilebilirler. Buna göre firmaların yenilik eylemlerini betimleyen değişkenleri ile bir gizli sınıf analizi yapılmış ve yenilikçi firmaların taksonomisi oluşturulmuştur. Gizli sınıf analizinden elde edilen sonuçların desteklenmesi ve sektör içindeki teknolojik rejimlerin belirlenmesi için, gizli sınıf analizinde de kullanılan değişkenlerden yararlanılarak faktör analizi yapılmış ve sektör içindeki yenilik biçimleri belirlenmiştir. Yukarıda açıklandığı gibi firmanın kaynak pozisyonu, yenilik stratejisi üzerinde de önemli bir etkiye sahiptir. Bu doğrultuda firmanın yenilik stratejisini etkileyen etmenlerin belirlenmesi için sınıflama ağacı yönteminden faydalanılmıştır. Bu tezin araştırma amaçlarından bir tanesi sektör içi yenilik davranışlarında görülen çeşitliliğin nicel hale getirilmesidir. Bu doğrultuda, biyolojik çeşitlilik çalışmalarında kullanılan Simpson endeksinden ve tez kapsamında oluşturulan yenilikçi firma sınıflamasından faydalanılarak sektör içindeki firma çeşitliliği nicel hale getirilmiştir. Çeşitliliğin farklı boyutlarını ele almak için faktör analizi yöntemi ile belirlenen yenilik biçimleri kullanılarak entropiye dayanan bir çeşitlilik endeksi de hesaplanmıştır. Sektör içi çeşitliliğin farklı ölçüler kullanılarak nicel hale getirilmesinden sonra, sektör içi çeşitliliği etkileyen etmenlerin belirlenmesi için farklı yöntemler kullanılmıştır. Sektör içi çeşitliliğin kaynakları regresyon ağacı ve sabit etki modelleri ile incelenmiştir. Son olarak sektör içi çeşitliliğin yenilik sürecindeki etkileri Crépon – Duguet – Mairesse modelinin değiştirilmiş bir versiyonu ile araştırılmıştır.

3. Bulgular

3.1 Yenilikçi Firmaların Sınıflandırılması

Biyolojik anlamda taksonomi canlı türlerinin belirlenmesi, sınıflandırılması ve adlandırılması ile ilgilidir. Gizli sınıf analizi ile sınıflandırılan firmaların belirli yenilik eylemlerini yapma olasılıkları hesaplanmıştır. Bu olasılıklar ve elde edilen sınıfların betimleyici istatistikleri ile ortaya çıkan yenilikçi firma gruplarının özellikleri yorumlanmaya çalışılmıştır. Yapılan analiz sonucunda altı yenilikçi firma grubu belirlenmiştir:

Grup 1 – Yüksek Profilli Yenilikçi Firmalar: Bu grup daha çok büyük firmalardan oluşmaktadır. En yüksek yenilik harcaması yoğunluğu da bu grupta gözlemlenmiştir. Piyasa için yeni ürün geliştirme ve süreç yeniliği yapma olasılığı en yüksek olan gruptur. Yenilikle ilgili ekipman yatırımı yapma, dış bilgi satın alma, personelin yenilikle ilgili eğitimi ve yenilik faaliyetleri ile alakalı pazarlama faaliyeti gerçekleştirme eğilimi de en fazla bu grupta gözlenmiştir. Ayrıca en yüksek işbirliği yapma eğilimi bu grupta yer alan firmalardadır. Yüksek profilli yenilikçi grubunda yer alan firmaların ayırt edici özellikleri büyük ölçek ve yüksek yatırım yapma kapasiteleridir. Bu nedenle yüksek profilli yenilikçi firmaların Schumpeter'in Mark II modeline uygun örnek teşkil ettiği söylenebilir.

Grup 2 – Verimlilik Arayışındaki Düşük Profilli Firmalar: Bu grupta yer alan firmaların ayırt edici özelliği yenilikle ilgili yatırım seviyelerinin düşüklüğüdür. Küçük ve orta ölçekli firmalar bu grupta çoğunluktadır. Bu grupta yer alan firmaların süreç yeniliği ve organizasyonel yenilik yapma olasılıkları yüksektir. Bu grupta yer alan firmaların yatırım yükü getirmeyen küçük ayarlamalarla süreç yeniliği ve organizasyonel değişiklikler yaparak verimliliklerini artırmayı hedefledikleri söylenebilir.

Grup 3 – Teknoloji Odaklı Yenilikçi Firmalar: Orta ölçekli firmalar bu grupta çoğunluğu oluşturmaktadır. Bu grupta yer alan firmaların firma içi Ar-Ge yapma olasılığı ve yenilik yatırımı yoğunluğu en yüksek ikincidir. Diğer taraftan organizasyonel ve pazarlama yeniliği yapma eğilimleri düşüktür.

Grup 4 – Pazar Odaklı Yenilikçi Firmalar: Bu grupta yer alan firmaların belirleyici özelliği pazarlama ve organizyonel yenilik yapmaya olan yüksek eğilimleridir. Ayrıca diğer firmalarla işbirliği konusunda en yüksek ikinci eğilim bu grupta yer alan firmalardadır.

Grup 5 – Süreç Odaklı Yenilikçi Firmalar: En düşük yeni ürünlerden elde edilen gelirin toplam gelire oranı bu grupta yer alan firmalarda görülmektedir. Bu grupta yer alan firmalar süreç yeniliğine ve yenilik için ekipman yatırımı yapmaya eğilimlidir. Küçük ve orta ölçekli firmalar bu grupta çoğunlukta olsa da büyük ölçekli firmaların da önemli bir mevcudiyeti bulunmaktadır.

Grup 6 – Düşük Profilli Ürün Yeniliği Firmaları: Bu grup daha çok küçük ölçekli firmalardan oluşmaktadır ve bu firmaların yenilik ile ilgili eylemleri gerçekleştirme olasılığı diğer gruplarda yer alan firmalara göre daha düşüktür. Ayrıca bu grupta yer alan firmaların yenilikle ilgili yatırım yoğunluğu da göreceli olarak azdır. Diğer taraftan firma için yeni ürünlerden elde edilen gelirin toplam gelire oranı en yüksek olarak bu grupta gözlemlenmiştir. Buna göre bu grubun taklide dayalı bir yenilik anlayışına sahip küçük firmalardan oluştuğu söylenebilir.

3.2 Yenilik Biçimleri

Bazı güncel çalışmalar, sektörlere özgü olmayan gizli yenilik örüntüleri olabileceğini ortaya koymuştur. Buna göre bir önceki aşamada kullanılan değişkenlerden faydalanarak faktör analizi yapılmış ve Türkiye'deki yenilik örüntüleri ile ilgili dört faktör belirlenmiştir.

Faktörlerdeki yükleme değerlerine göre birinci faktör teknoloji odaklı ürün yeniliği örüntüsü olarak tanımlanmıştır. Yenilikle ilgili farklı yatırım türleri ile piyasa için yeni ürünlerle ilgili değişkenlerin bu faktördeki ağırlığı daha fazladır.

Süreç yeniliği ve organizasyonel yenilik ile ilgili değişkenlerin ağırlığı nedeniyle ikinci faktör verimlilik odaklı yenilik örüntüsü olarak adlandırılmıştır. Ayrıca makine ve teçhizat yatırımları ile ilgili değişkenin en yüksek ağırlığı bu faktördedir.

Üçüncü faktör pazar odaklı ürün yeniliği örüntüsü olarak adlandırılmıştır. Pazarlama yeniliği ile ilgili değişkenlerin yanı sıra ürün yeniliği ile değişkenlerin bu faktördeki ağırlığı yüksektir. Firma için yeni ürün yeniliği ve süreç yeniliği ile ilgili değişkenlerin yüksek ağırlığı nedeniyle son faktör taklide dayalı yenilik örüntüsü olarak adlandırılmıştır.

3.3 Sektör İçi Çeşitliliğin Firma Seviyesindeki Belirleyici Etmenleri

Veri setindeki firmaların hangi yenilik grubunda yer aldığı firmaların kaynak durumu, bilgi tabanı ve diğer kurumlarla olan ilişkilerin betimleyen değişkenleri kullanan bir özyineli ayrıştırma modeli ile analiz edilmiştir.

Kullanılan model yüksek yenilik harcaması yoğunluğu olan büyük firmaları Yüksek Profilli Yenilikçi Firmalar kategorisine yerleştirmiştir. Sınıflama ağacının bu dalında yer alan firmaların daha geniş bir bilgi tabanından yararlandığı, müşteri ve tedarikçileri ile işbirliğine eğilimli oldukları görülmektedir.

Diğer taraftan düşük seviyede yenilik yatırımı olan küçük firmalar genellikle Verimlilik Arayışındaki Düşük Profilli Firmalar ya da Düşük Profilli Ürün Yeniliği Firmaları gruplarına atanmıştır. Kestirim sonuçları irdelendiğinde, kullanılan modelin Düşük Profilli Ürün Yeniliği Firmaları grubuna aidiyeti Verimlilik Arayışındaki Düşük Profilli Firmalar grubuna aidiyetten daha iyi tahmin edebildiği görülmektedir. Buna göre Yüksek Profilli Yenilikçi Firmalar ve Düşük Profilli Ürün Yeniliği Firmaları gruplarının bir zıtlık oluşturduğu söylenebilir. Ancak analiz sonuçları böyle bir zıtlıktan daha karmaşık bir yapının varlığını göstermektedir. Özyineli ayrıştırma algoritması yenilik harcaması yoğunluğu göreceli daha düşük olan firmaları Teknoloji Odaklı Yenilikçi Firma grubuna atamıştır. Müşterileri ve tedarikçilerini bilgi kaynağı olarak kullanan ve onlarla işbirliği yapan küçük ve orta ölçekli firmalar genellikle Pazar Odaklı Yenilikçi Firmalar grubunda yer almıştır.

Sınıflama ağacı analizi sonuçları firmanın kaynak durumunun, bilgi tabanının çeşitliliği ve genişliğinin ve firmanın diğer kurumlarla işbirliği yapma yetkinliğinin yenilik stratejisi üzerinde etkili olduğunu göstermiştir. Elde edilen bulgular teorik çerçeveyi destekler niteliktedir. Buna göre firma seviyesindeki etmenler firmanın farklı yenilik davranışları geliştirmesine yol açmakta ve bu nedenle sektör içindeki yenilik davranışları da çeşitlilik göstermektedir.

3.4 Sektör İçi Çeşitliliğin Nicelleştirilmesi

Simpson ve entropi endeksleri kullanılarak sektör içi yenilik davranışlarının çeşitliliği nicel hale getirilmiştir. Simpson endeksi ile sektördeki ortalama firma büyüklüğü arasında negatif bir korelasyon olduğu görülmüştür. Ancak entropi endeksi ve ortalama firma büyüklüğü arasındaki ilinti bu kadar güçlü değildir. Sektördeki ortalama firma büyüklüğü seçim mekanizmasının bir göstergesi olarak kabul edilirse sektördeki çeşitliliğin sektör içindeki seçim süreçleri ile indirgendiği söylenebilir.

Simpson ve entropi endekslerinin sektördeki ortalama yenilik harcaması ile doğru orantılı olarak arttığı görülmüştür. Bu bulgu farklılaşımın fazla olduğu ortamlarda çeşitliliğin de arttığını gösterdiği için tezin teorik çerçevesi ile uyumludur.

3.5 Sektör İçi Çeşitliliğin Sektör Seviyesindeki Belirleyici Etmenleri

Sektör içi çeşitliliğin makro seviyedeki belirleyici etmenlerinin tespit edilmesi için regresyon ağaçları ve sabit etki modelleri kullanılmıştır. Simpson endeksi için oluşturulan regresyon ağacı sonuçlarına göre sektörde Ar-Ge yapan firmaların oranı, sektör içi çeşitliliğin en önemli belirleyici etmenidir. Buna göre Ar-Ge yapan firmaların getirdiği yenilikler sektör içindeki farklılaşım mekanizmalarına katkı sağlamakta ve sektör içindeki çeşitliliğin artmasına neden olmaktadır.

Makine ve teçhizat alımı şeklinde gerçekleşen örtülü teknoloji transferi firmaların kendi bünyelerinde gerçekleştirdikleri Ar-Ge ve yenilik faaliyetlerini tamamlayıcı nitelikte olabilir. Ancak analiz sonuçlarına göre bu türden yatırımı olan firmaların sektördeki oranı %21'in üzerinde ise sektör içi çeşitlilik azalmaktadır. Bu durumda örtülü teknoloji transferi yapan firmaların kendi bünyelerinde yenilik faaliyetlerinde bulunmamayı tercih ettiği ve bunun da sektördeki farklılaşım mekanizmasını yavaşlatarak sektör içi çeşitliliği azalttığı iddia edilebilir. Bu etki, sektör içinde süreç yeniliği yapan firmaların oranı %31'in altında olduğunda daha çok görülmektedir. Diğer taraftan sektör içinde mikro ölçekli firmaların ya da süreç yeniliği yapan firmaların oranı arttıkça sektör içi çeşitlilik de artmaktadır. Bu bulguya dayanarak yeni süreçlerin geliştirilmesinde etkin olan öğrenme mekanizmalarının firmaları farklı yenilik stratejilerine yönlendirdiği söylenebilir. Buna göre örtülü teknoloji transferi, süreç yeniliği ile birleştirildiğinde sektördeki farklılaşım mekanizmalarına katkı sağlamaktadır.

Diğer kurumlarla işbirliği yapan firmaların oranı ve yabancı menşeli firmaların oranı yükseldikçe Simpson endeksi ile nicel hale getirilen sektör içi çeşitlilik artmaktadır. Bu etki sektörde Ar-Ge yapan firmaların oranı %12'den düşükse daha çok hissedilmektedir. Bun göre Ar-Ge faaliyetlerinin yoğun olmadığı sektörlerde firmalar arasındaki bilgi alışverişi farklılaşım mekanizmalarına katkı sağlamaktadır. Sektördeki küçük firmaların oranı arttıkça Simpson endeksinin de arttığı görülmektedir. Sektördeki küçük firmaların oranı sektöre girişin bir göstergesi olarak kabul edilirse yeni firma girişinin farklılaşım mekanizmaları ile pozitif bir ilişkisi olduğu söylenebilir.

Entropi endeksi için yapılan regresyon analizi sonuçları, çalışan başına düşen yenilik harcamasının sektör seviyesindeki ortalamasının sektör içi çeşitliliğin seviyesini belirleyen en önemli etmen olduğunu göstermektedir. Ayrıca yabancı menşeli firmaların oranı, bir gruba dahil olan firmaların oranı ve ürün yeniliği yapan firmaların oranı da sektör içi çeşitliliği belirleyen önemli etmenler olarak ortaya çıkmaktadır.

Entropi endeksi ile ölçülen sektör içi çeşitlilik, ortalama yenilik harcaması ve ürün yeniliği yapan firmaların oranı ile beraber artmaktadır. Buna göre yenilik için yapılan yatırımlar sektör içi farklılaşım mekanizmalarına katkı sağlamaktadır. Diğer taraftan bir gruba dahil olan firmaların oranı arttıkça sektör içi çeşitlilik de azalmaktadır. Grup içi ortak iş yapma biçimlerinin yenilik stratejilerin çeşitliliğini de kısıtladığı söylenebilir. Sektördeki yabancı firmaların oranı, entropi endeksini Simpson endeksinden daha fazla etkilemiştir. Buna göre yabancı firmaların sektöre dışarıdan bilgi taşıdığı ve bu bilgi alışverişinin sektördeki farklılaşım mekanizmalarına pozitif etkisi olduğu söylenebilir.

Regresyon ağacı analizinden elde edilen sonuçların sabit etki modelleri ile doğrulanması için çalışılmıştır. Simpson endeksi için sabit etki modeli kestirimlerinden elde edilen sonuçlar regresyon analizi sonuçları ile benzeşmektedir. Buna göre Ar-Ge yapan, diğer kurumlarla işbirliğine giden ya da süreç yeniliği yapan firmaların oranı arttıkça sektör içi çeşitlilik de artmaktadır. Diğer taraftan sektördeki ortalama firma büyüklüğü arttıkça çeşitlilik anlamlı biçimde azalmaktadır. Makine ve teçhizata yapılan yatırımlar sektör içi çeşitliliği önemli ölçüde azaltmaktadır.

Entropi endeksi için yapılan sabit etki modeli kestirimlerine göre yenilik harcaması yoğunluğu sektör içi çeşitliliği anlamlı biçimde artırmaktadır. Entropi endeksi ve sektördeki yabancı menşeli firmaların oranı arasına ters u şeklinde bir ilişki bulunmuştur. Bu bulgu, yabancı firmaların sektörde yoğunlaşmasının çeşitliliği bir ölçüye kadar artırdığını göstermektedir. Farklı yenilik stratejileri olan yabancı firmalar sektörde faaliyet gösterdiğinde yerel firmalar rekabet için farklı stratejiler geliştirebilir ya da yabancı firmalardan öğrendikleri teknikleri başka biçimlerde uygulamaya alabilir ve bu nedenlerle sektör içindeki çeşitlilik artabilir. Diğer taraftan yabancı firmaların yarattığı rekabet baskısı yerel firmaları piyasa dışına iterek sektördeki çeşitliliğin azalmasına neden olabilir. Ayrıca yabancı firmaların tedarik zincirinde yer alan yerel firmalar doğrudan bağlı oldukları firmaların stratejilerine uygun hareket ettiklerinde de sektör içi çeşitlilik azalabilir. Bir gruba dahil olan firmaların oranı arttıkça sektör içi çeşitlilik azalmaktadır. Bu bulguya dayanarak standartlaşmış yenilik uygulamaları ve artan firma büyüklüğünün sektör içindeki yenilik stratejilerinin çeşitliliğini azalttığı söylenebilir.

3.6 Sektör İçi Çeşitlilik ve Firma Performansı

Sektör içi çeşitliliğin firma performansı ve firmanın yenilik süreçleri üzerindeki etkilerinin belirlenmesi için Crépon – Duguet – Mairesse tarafından önerilen modelin farklı bir versiyonu ile kestirimler yapılmıştır. OECD tarafından kullanılan model bu teze adapte edilmiştir. Temel model kestirim sonuçlarına göre Türkiye’de yeniliğe yönelik yatırım yapma eğilimi firma büyüklüğü ile beraber artmaktadır. Bunun yanında bir gruba dahil olan ya da ihracat yapan firmalar da yenilik yatırımı yapmaya daha yatkındır.

Yenilik harcamalarının yoğunluğu dikkate alındığında bir gruba dahil olmanın anlamlı bir pozitif etkisi olduğu görülmüştür. Ayrıca Ar-Ge'ye yönelik kamu desteklerinden faydalanan firmalar da benzerlerine göre daha fazla yenilik harcaması yapmaktadır.

Modeldeki bilgi üretimi eşitliği incelendiğinde, yenilik harcamaları ile yeni ürünlerden elde edilen gelir arasında anlamlı bir pozitif ilişki olduğu görülmüştür. Diğer taraftan süreç yeniliği de yeni ürünlerden elde edilen gelir miktarını artırmaktadır. Buna göre ürün ve süreç yeniliğinin birbirini tamamladığı söylenebilir.

Kestirim sonuçları, çalışan başına yeni ürünlerden elde edilen gelirdeki %1'lik artışın %0,8'lik üretkenlik artışına neden olduğunu göstermektedir. Elde edilen sonuçlar büyük firmaların Türkiye'de daha üretken olduğunu göstermektedir.

Bir sonraki adımda Simpson endeksi ve entropi endeksi modellere dahil edilerek sektör içi yenilik davranışlarındaki çeşitliliğin firma üzerindeki etkileri belirlenmiştir. Elde edilen sonuçlara göre Simpson endeksi ve entropi endeksi ile firmaların yenilik harcamaları arasında pozitif bir ilişki vardır. Buna göre çeşitliliğin fazla olduğu ortamlarda faaliyet gösteren firmalar yeniliğe daha fazla yatırım yapma eğilimindedir.

Bilgi üretimi tarafında da her iki endeksin yeni ürünlerden elde edilen gelirlerle anlamlı bir pozitif ilişkisi olduğu görülmektedir. Simpson endeksinin üretkenliğe negatif etkisi olduğu bulunmuşsa da bu etkinin istatistiki olarak anlamlılığı doğrulanamamıştır. Diğer taraftan entropi endeksinin yüksek olduğu sektörlerde faaliyet gösteren firmaların daha üretken olduğu sonucuna ulaşılmıştır.

CDM modeli kestirimlerinden elde edilen sonuçlar yenilik sürecinin karmaşıklığını da göstermektedir. Farklı mekanizmalar değişik seviyelerde çalışmakta ve birbirleriyle etkileşime girmektedirler. Analiz sonuçları sektör içi çeşitliliğin bu mekanizmalar üzerinde önemli bir etkisinin olduğunu göstermektedir. Yenilik davranışlarının çeşitliliği ile ön plana çıkan sektörler, bilgi üretimi ve bilginin ekonomik değere dönüşümü için uygun ortamlar oluşturmaktadır. Elde edilen araştırma bulguları yenilik sektörünün ayırt edici özelliklerinin karmaşıklık ve çeşitlilik olduğunu göstermektedir. Bu nedenle yenilik politikaları bu özellikleri gözetecek biçimde yapılmalıdır. Tezin uygulamalı kısmından elde edilen bulgulara dayanarak geliştirilen politika önerileri bir sonraki kısımda özetlenmektedir.

4. Politika Önerileri

Kay'a göre (2006) politikalar politika yapma sürecinden bağımsız olarak ele alınamaz. Bu tezin uygulamalı kısmından elde edilen bulgulara dayanarak yenilik politikaları için yeni bir çerçeve önerildikten sonra bu çerçeve dahilinde daha somut politika önerileri geliştirilecektir.

Bilim, teknoloji ve yenlik politikalarının hedeflediği alanların belirlenmesi süreci, bu alanlardaki problemlerin çözümü kadar önemlidir. Herhangi bir zamanda politika alanı, karmaşık bir seçim ortamında birbiri ile rekabet eden birçok fikirle doludur. Bir fırsat penceresi oluştuğunda seçim sürecinden geçen fikirler ön plana çıkabilmektedir. Bu fırsat penceresinden geçen politik fikir akımı kademeli bir gelişim ile ani değişiklikleri bir araya getirmektedir. Mevcut politikaların yaratıcı yıkım ile değişmesinden sonra yeni ortaya çıkan politikaların yerleşmesi için yapılan kurumsal ayarlamalar gelmektedir. Türkiye'deki politika odağının kaliteden Ar-ge ve yeniliğe ve daha sonra da teknoloji tabanlı girişimciliğe olan kayması bu duruma örnek gösterilebilir.

Schumpeter'in girişimcisine benzer şekilde politik girişimciler de bu fırsat pencerelerini kullanarak kendi önceliklerinin politik gündeme girmesini sağlayabilirler. Buna göre politik bir alanda alakalı olarak görülen aktörler kendi aralarında ikna ve pazarlık tekniklerini kullanarak amaçlarına ulaşmaya çalışırlar. Bu nedenle politika alanında aktörlerin alakasının belirlenmesi büyük önem taşımaktadır.

2011 – 2016 Ulusal Bilim Teknoloji ve Yenilik Stratejisi'nin hazırlanmasında özel sektör, TÜBİTAK'tan en fazla destek alan firmalar tarafından temsil edilmiştir. Buna göre politika yapıcının sağladığı destek miktarı ile firmanın yenilik performansı arasında bir ilişki kurduğu görülmektedir. Tezde yapılan sınıflama çalışması, farklı yenilik stratejisine sahip birçok firma olduğunu göstermektedir. Bu gruplardan bazılarının yenilik politikalarının oluşturulması süreçlerinin dışında bırakılması, politikaların belirli ilgi gruplarının önceliklerine göre şekillenmesine neden olabilir. Politika yapıcıların amaçları ve ilgi gruplarının öncelikleri kendini destekleyen bir yapıya dönüşerek bir kilitlenmeye neden olabilir.

Örnek olarak politika yapıcılar yenilik sürecini tek bir boyuta indirgeyerek Ar-Ge harcamalarını hızlı biçimde artıracak çözümleri tercih edebilirler. Bu durumda Ar-Ge yatırımları için ek desteğe ihtiyaç duyan aktörler de bu politikaları destekler. Diğer taraftan Ar-Ge harcamalarının yoğun biçimde kamu kaynakları ile desteklenmesi, firmaların bu desteklere bağımlı hale gelmesine ve daha fazla destek almadan faaliyetlerini sürdürememelerine neden olabilir. Herhangi bir nedenle kamu desteğinin kesilmesi ya da azalması bütün yenilik sisteminin performansını tehdit eder hale gelecektir. Bu örneğin gösterdiği gibi politika yapma sürecindeki geri besleme mekanizmaları izlek bağımlılığına yol açmakta ve bu da bütün sistemi kırılgan hale getirmektedir. Bu nedenle bilim, teknoloji ve yenilik politikaları izlek bağımlılığından kaynaklanan riskleri önleyecek şekilde yeniden yapılandırılmalıdır. Buna uygun olarak politikaların başlangıç noktası ulusal, sektörel ya da bölgesel yenilik sistemlerinin detaylı biçimde analizi olmalıdır. Politikalar farklı seviyelerdeki karmaşık mekanizmaları ve bunların etkileşimini yansıtacak biçimde oluşturulmalıdır. Yenilik süreçlerinin detaylı analizi, politika alanında alakalı olarak görülen aktörlerin sayısının artmasına ve herhangi bir grubun dışarıda bırakılmamasına katkı sağlayacağı gibi yenilik süreçlerinin altında yatan farklı mekanizmaların anlaşılmasıyla daha sağlam politika amaçları ortaya konabilir. Farklı seviyelerdeki yenilik sistemlerinin detaylı analizi ile politikaların hedef kitleleri de daha sağlıklı biçimde tanımlanabilir.

Önerilen politik çerçevenin bir sonraki adımı problem alanındaki ihtiyaçların belirlenmesi ve politikaların hayata geçirilmesi için gereksinimlerin saptanmasıdır. Politika amaçları problem alanının sınırlarını belirlemekteyken, gereksinim analizi hazır çözümlerden bir seçim yapılması ya da yeni çözümlerin geliştirilmesi konusunda içerik sağlamaktadır. Buna göre işlevsel gereksinimler problem alanındaki sürükleyici, kolaylaştırıcı ya da engelleyici faktörlerin belirlenmesini kapsamaktadır. Bu aşamada politika amaçlarına ve işlevsel gereksinimlere göre performans gereksinimleri de ortaya konmalıdır. Performans gereksinimleri daha sonraki aşamalarda etki analizi için de kullanılabilir.

Önerilen politik çerçevedeki risk yönetimi, yenilik sisteminin dirençliliğinin artırılması fikrine dayanmaktadır. Buna göre risk önleme stratejisi ve uygun politika araçlarının seçimi, daha esnek çözümlerin katı önerilere tercih edilmesi ile sistemin genel dirençliliğini artırılmasını hedeflemelidir. Bir sistemin dirençlilğinin artırılabilmesi için mevcut uygulamaların ve politikaların sürekli olarak gözden geçirilmesi gerekmektedir. Önerilen politik çerçevenin önemli adımlarından bir tanesi de etki analizi kavramının kurumsallaşması ve politika araçlarının sürekli gözden geçirilmesidir.

Türkiye’deki mevcut bilim ve teknoloji politikası dokümanları incelendiğinde farklı kamu kurumları tarafından uygulanan politikaların bazı önemli eksikleri olduğu görülmektedir. İlk olarak mevcut politika ve stratejiler politika yapıcıların öne sürdüğü varsayımlara ve tipolojilere dayanmaktadır. Diğer taraftan, bu tezden elde edilen bulgular birçok farklı yenilik stratejisinin bulunduğunu göstermektedir. Bu nedenle sektörlere ya da firma ölçeğine göre yapılan ayrımlar, uygulamaya alınan bir politikanın etki alanında yer alan firmaların gereksinimlerinin belirlenebilmesi için yeterli değildir. Politika yapma süreci ilgili aktörlerin detaylı analizi ve bu aktörlerin yenilik süreçleriyle ilgili sürükleyici, kolaylaştırıcı ya da engelleyici faktörlerin belirlenmesi ile başlamalıdır. Bu bağlamda dar bir grubun çıkarları doğrultusunda oluşturulan uygulamalar, politika alanında kırılmalara neden olmaktadır. Bu nedenle önerilen ilk politika teması yenilik politikalarının bütünlüğü ve tutarlılığı olarak adlandırılmıştır. Buna göre kapsayıcılığı daha fazla olan az sayıdaki politika aracı, dar kapsamlı ancak çok sayıdaki politika aracının kombinasyonuna tercih edilmelidir. Örnek olarak Ar-Ge ve yeniliğin desteklenmesi konusunda birçok bakanlık ve kamu kurumu birbirine çok benzeyen programlar yürütürken, hedef kitlelerindeki firmaların farklı özelliklerini ihmal etmektedirler.

Bilim, teknoloji ve yenilik politikalarının oluşturulmasında akut ve kronik problemler arasında bir ayrıştırma yapılmalıdır. Kronik problemler sistemsel başarısızlıklara ve bütün sistemin işlevsiz hale gelmesine neden olabilecekken, sistemin tolerans sınırları içinde kalan akut problemler herhangi bir ek müdahaleye gerek kalmadan çözülebilirler. Önerilen politik çerçeve, yenilik sistemlerinin dirençliliği ve problem çözme kapasitesinin çeşitlilik ile geliştirilebileceğini savunmaktadır. Buna göre politika yapıcılar kronik problemlere odaklanırken, akut problemleri değişim ve sistemin gelişme alanlarının belirlenmesi için sinyaller olarak algılamalıdır.

Bu tez bir yenilik sistemi içerisinde çoklu yenilik davranışlarının bir arada olmasının sistemin dirençliliğini ve şoklara dayanma kapasitesini artırdığını öne sürmektedir. Elde edilen bulgular, sektör içi çeşitliliğin farklılaşım ve seçim mekanizmaları ile ilgili olduğunu göstermektedir. Yeni firmaların piyasaya girişi farklılaşım mekanizmalarına katkı sağlamaktadır. Bu durumda yeni teknoloji tabanlı firmaların desteklenmesi ile yenilik sistemi içinde çeşitlilik yaratmak mümkün olabilir. Mevcut politikalar, Amerika Birleşik Devletleri'ndeki başarı öykülerinden etkilenerek yeni teknoloji tabanlı firmaların sadece yüksek büyüme potansiyeline vurgu yapmaktadır. Diğer taraftan önerilen politik çerçeve teknoloji tabanlı firmaları birer bilgi deposu olarak görmekte ve onların yenilik sistemi içerisinde yerine getirdiği işlevlere odaklanmaktadır. Bazı başlangıç firmaları hızı bir büyüme süreci içine girebilirken bazıları karlı niş pazarlar bularak küçük kalmayı tercih etmekte, ancak yine de yenilik sistemi içerisinde önemli işlevler üstlenmektedirler. Bu bağlamda yeni başlangıç firmalarına yönelik uygulamalarda bir portföy yaklaşımı geliştirilmeli ve firmalar yenilik sisteminde yerine getirebilecekleri işlevler dikkate alınarak desteklenmelidir.

Elde edilen bulgular kurumlar arasındaki işbirliğinin sektör içindeki farklılaşım mekanizmalarına pozitif katkı yaptığını göstermektedir. Bu etki özellikle Ar-Ge yoğunluğunun düşük olduğu sektörlerde daha fazladır. Buna göre farklı yenilik stratejilerine sahip aktörlerin bir arada olabileceği sektörel ve bölgesel küme yapıları desteklenerek bilgi alışverişi kolaylaştırılmalıdır. Analiz sonuçları sisteme dış bilgi aktarımının da çeşitliliğe olumlu etkisi olduğunu göstermektedir. Buna göre yerel firmaların yabancı menşeli firmaların yenilik süreçlerine dahil olması ile sektör içi çeşitlilik geliştirilebilir.

APPENDIX G – TEZ İZİN FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☒ X

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : Yurtseven
Adı : Alp Eren
Bölümü : Bilim ve Teknoloji Politikası Çalışmaları

TEZİN ADI (İngilizce) : Sources and Determınants Of Intra-Industry Heterogeneıty in The Innovatıon Process

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora X

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. X
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. ☐

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: