POLICY IMPLICATIONS IN THE LEARNING ECONOMY
A STUDY ON LEARNING PROCESS MODEL OF ASELSAN

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ABSTRACT

POLICY IMPLICATIONS IN THE 'LEARNING ECONOMY'
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This study explores the relatively new concept of "The Learning Economy" in the context of system of Innovation, which provides a basic understanding of all elements and their relations necessary to enhance the innovative capacity. This thesis aims to examine the structure and characteristics of ASELSAN (Electronic Industries Inc.) including i.e., firm-level technological activities. In the 'Learning Economy', rapid learning is the key factor for accelerating innovative capabilities and competitiveness for firms and nations. On the other hand, this concept is closely correlated with the 'New Economy', ICT (Information communication Technologies) that enhances the knowledge dissemination and learning. In this perspective, ASELSAN acquired high-level technological capabilities and rapid development such that it can be considered as a model for other firms in Turkey. Furthermore, this research aims to point out the 'Learning Process Model of ASELSAN' comparing it with the catching-up firms in South Korea and emphasize transformation of technology and institutional structure in the period from 1980 to 2002. As an individual firm, 'ASELSAN' is a leading firm in the defense industry as a system integrator; and the next step may be 'network-based' learning process model. In summary, there could be policy lessons to be taken for other firms to become a 'learning organization and 'innovative firm'.

Keywords: Learning Economy, innovation, learning process, technological capability, and organization, Turkish Electronic Industry

ÖZ

‘ÖĞRENEN EKONOMİ’ DE POLİTİKA ÖNERİLERİ
ASELSAN’IN ÖĞRENME SÜRECİ MODELİ ÜZERİNE BİR ÇALIŞMA

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Yenilik kavramı yenilikçi kapasitenin iyileştirilmesi için gerekli olan tüm unsurlar ve bu unsurlar arasındaki ilişki hakkında temel bir anlayış ortaya koymaktadır. Bu çalışma, göreceli olarak yeni olan ‘öğrenen ekonomi’ kavramını yenilik sistemi bağlamında araştırmaktadır. Bu tez, ASELSAN (Elektronik Sanayi ve Ticaret A.Ş.)’ın yapısını ve karakteristiklerini (firma bazında teknolojik faaliyetleri gibi) incelemeyi amaçlamaktadır. Öğrenen ekonomide, hızlı öğrenme, firmaların ve ulusların yenilikçi yeteneklerini ve rekabetçi güçlerini hızlandıran esas faktördür. Diğer taraftan bu kavram, bilgi yayılmasını ve öğrenmeyi artıran yeni ekonomi, Bilgi İletişim teknolojileri (ICT) ile de yakından ilişkilidir. ASELSAN bu perspektif ile ileri teknoloji yetenekleri kazanmış ve hızlı kalkınma sağlamış olup, ASELSAN’ın Türkiye’deki diğer firmalar için bir örnek teşkil edilebileceği düşünülmektedir. Bu araştırma, ayrıca Güney Kore’deki yeni gelişen (catching-up) firmaların öğrenme süreci modellerine atıfla ASELSAN’ın öğrenme modelini ele almakta ve 1980-2002 yılları arasındaki kurumsal yapısı ile teknoloji transferini vurgulamaktadır. ASELSAN, tek bir firma olarak, savunma sanayiinde lider bir firma olduğu ve sistem entegratörü rolü oynadığı için, öğrenme sürecinin bir sonraki adımının ‘ağa dayalı model’ çerçevesinde değerlendirilmesi önerilmektedir. Sonuç olarak, diğer firmaların ‘öğrenen organizasyon’ ve ‘yenilikçi firma’ olmaları için bazı politika önerileri bulunmaktadır.

Anahtar kelimeler: Öğrenen ekonomi, yenilik (inovasyon), öğrenme süreci, teknolojik yetenek ve organizasyon, Türk Elektronik Sanayi.

To My Parents

And

My Daughters

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INTRODUCTION

1.1. Introducing The 'Learning Economy' and The Thesis

One of the most fundamental trends in the world economy over the last decades has been the accelerating rate of innovation and change, driven by the intensified competition in many products and service markets. The faster rate of innovation and change are closely related with the transition towards a global economy since the 1970s. The globalization of production, trade and financial markets (i.e., the political decisions about deregulation and market liberalization) are strongly interrelated to each other. Globalization has a direct impact on firms belonging to different (industrial) sectors and territories, through intensified competition. This means that the economic performance in this new economic context increasingly depends on the learning ability of individuals, firms, regions and countries. Learning is necessary to adapt to the rapidly evolving market and technical conditions and to achieve innovation of processes, products and forms of organization.

According to the results of a recent economical research, the modern economy may be described as knowledge-based, or a learning economy, due to the central and crucial role that knowledge and learning play in the economic development of firms as well as for the society in general (OECD, 1996a). The second characteristic of current developments is that the economic activity is gradually becoming more globalized, both in terms of scope and structure. A third observation is that the increased knowledge content of economy combined with the process of globalization has led to a situation that is more important than ever before for the economic development (Morgan, 2001).

There has been a transition from an industrial to a knowledge-based or learning economy and society (OECD, 1996b) since the recent decades. There has been a widespread mutual understanding that the production and distribution of knowledge are becoming increasingly significant processes in the determination of economic development and competitiveness. The latter is reflected in economic growth, employment change and levels of welfare. This has enormous implications for organizations and firms, educational organizations, R&D institutes, departments and agencies of the state, intermediate organizations – as well as for individuals within educational and labor market. The capacity of both organizations and individuals to engage successfully in learning processes of a variety of kinds has come to be regarded as a crucial determinant of economic performance (Lundvall and Johnson, 1994).

The development of the learning economy involves a complexity of economic and social processes. The emergent forms of economic activity affect the characteristic nature of work and the types and levels of skills required in the economy. As a result, these developments have raised concerns about the capacity of educational systems to fulfill new requirements with respect to learning.

Starting from the most influential branch of economic ideas in the 20th century, namely neoclassical economics, one of the main problems of this theory was that it explained economic performance in terms of a production function consisting of the interaction between two factors: **labor** and **capital**. This implied that the growth of the economy could only take place by increasing one or both of these factors, which corresponded poorly with empirical observations of economic processes in firms, industries and societies in general. Moreover, the two production factors were assumed to operate under conditions of perfect competition. The latter implies that all economic agents possess the same information of market opportunities and other vital facts due to the requirement of perfect information; assuming constant returns to scale, which poses a major problem in explaining how and why technological changes may come about. Neo-classical economics does not effectively recognize the effects of social and institutional factors on the formation of knowledge, and macroeconomic phenomena, such as economic growth, are explained as a result of firms' individual actions.

The traditional neo-classical economics offered no endogenous explanation for the process of economic growth; as a result, an exceedingly heterogeneous and rich body of literature has developed attempting to escape these theoretical constraints. In particular, within the field that may be collectively referred to as *innovation economics*, a substantial effort has been put into scrutinizing the process of economic and technological change, keeping a particular eye on the role of knowledge and learning processes.

This is just one illustration of how globalization and the growing international interdependence tends to impose an even more ambitious and complex agenda for the development of low-income countries.

The Washington Consensus had a highly market-oriented view regarding the development, which emerged in the 1980's and this condition was reflected in the policy recommendations of international organizations such as OECD, IMF and the World Bank (Johnson and Lundvall, 2000). According to these international organizations, macroeconomic balance and 'getting prices right' were the key factors. Macroeconomic balance is accepted as an essential part of the development strategy, which affects the building institutions and the changing cultures. However, it is emphasized that it has to be complemented with institutional innovations. There is a new kind of competition where competence building and innovation has become important for all players in the global markets. Institutional learning and social capital are key elements in the new development strategies. The economics of development strategies have tended to create a dynamic production function factors such as; labor, capital, knowledge and nature (Stiglitz, 1998).

According to the 1999/2000 World Bank Development Report:

> Globalization and localization have been the main combined issue pointing to the growing importance of social and natural capital. Globalization means that the national governments need to seek agreements with other governments and international organizations. Localization requires them to cooperate with cities, regions and local communities. In this connection, the importance of social capital is emphasized. It is hard to emphasize the importance of networks of trust and association for sustainable development. (World Bank Development Report, 1999/2000, p.18).

Globalization – increasing interconnectedness in the world economy and increasing speed and volume of financial capital movements – increases the dependence of developing countries on economic decisions of high-income countries and specifically on short-term financial dispositions. The tendency towards a knowledge-based learning economy is particularly strong in the countries on or close to the technological front, but may nevertheless cause severe problems in developing countries, which do not have adequate knowledge infrastructures and institutional frameworks to capture the potential economies of this tendency.

Combining the Learning Economy and Globalization accepted as “globalizing learning economy” that the interconnections between geographically different parts of the world have increased the learning opportunities. The development of an integrated world economy has allowed acquiring information, expertise and technology at a faster pace and often lowers costs than in the past.

This thesis aims to analyze firm-level innovations, firm’s technological capabilities, and dynamics of the learning process and product development innovation in order to emphasize learning model of ASELSAN (Electronic Industries Inc.) as an example of ‘Learning Organization’ in the ‘Learning

Economy' of a developing country. The thesis begins with the definitions of "Learning Economy" and "National Innovation System" concepts. The second chapter defines Learning Economy and National Innovation System and gives policy consideration. The third chapter gives a literature review of types of learning and dynamics of learning organizations and learning economy to understand the importance of innovative reactions of firms and other organizations with the institutional perspective. The fourth chapter gives firm-level literature review about technological capability, technology transfer, technology life cycle, new product development, innovation and learning process models related with the studies in ASELSAN as an example of 'learning organization'. The fifth chapter aims to emphasize the rapid learning period as by comparing the individual latecomer-learning model and proposes the next learning model for ASELSAN, which is the 'network-based' learning model. The Conclusion chapter points out the policy implications from ASELSAN to other firms to develop and enhance competitiveness. There might be a necessity of effective and efficient National Innovation System of Turkey as soon as the 'Vision 2023 – Technology Foresight Program' is completed by TÜBİTAK (The Science and Technical Research Institution of Turkey).

1.2. Methodology and Scope of Thesis

As ASELSAN, being one of the most significant firms using and producing high technology in Turkey, has given priority, since its establishment, to well-educated human resources, R&D studies, and collaboration with universities in order to produce high technology- based equipment and systems; it was chosen as the case study in this thesis.

The purpose of the thesis is to explore how ASELSAN acquired technology and managed its entry into the international markets. The study identifies the learning mechanism of ASELSAN brought about by the diffusion of technology from advanced countries and how it set about improving and adapting foreign technology through rapid learning. This study concentrates on the learning process model of ASELSAN comparing with the individual learning latecomer model in East Asia since it started producing as a single firm in the defense industry. To demonstrate firm-level technology accumulation and transformation process, radio equipments were examined in the period 1980-2002 giving information about technology, design, test and engineering management. The learning mechanism of the firm was analyzed in four periods:

1. Technology Transfer/Technological Learning Period,
2. Original Design Equipment,
3. Original System,
4. System of Systems.

The methodology of this thesis includes a literature study, interviews and primarily internal data, company history and ASELSAN's magazines and annual reports and support of Mehmet Zaim (The Director of Planning and Knowledge Management Department in Microwave and System Technologies Division-MST) and Elif Baktır (The Technical Leader of Planning and Innovation Management Department in MST Division) with profound knowledge regarding ASELSAN.

CHAPTER 2

GLOBALIZATION AND THE "LEARNING ECONOMY"

This chapter aims at presenting a literature review of 'Learning Economy' in which rapid learning is the key factor in enhancing innovation capacity of firms and nations in a broader sense.

2.1. The Effects of Globalization

Globalization trends and growing importance for nations "to be innovative" in the past two decades, are parallel and interrelated phenomena influencing the world economy. Starting from the 1970s, a series of political and economic developments, such as the rise of Japan and other Asian economies (NICs), the end of the cold war period and the structural changes which resulted from these events, the formation of multinational regions like North America (NAFTA countries), Europe (EU countries) and East Asia (ASEAN countries), the liberalization of trade and financial markets, important developments in transport and communications, and new rapid technological advances, have all seriously transformed the world economy and brought new challenges to all nations' economies affected by these processes. Globalization – arising parallel to these events and being characterized by the increase of international trade, capital flows, foreign direct investments and technological alliances – especially led to an increased market competition. The rapid growth of the Dynamic Asian Economies (DAE) has also significantly contributed to the pressure of competition in the world markets.

However, globalization has not only increased market competition, but it has also transformed it into a market competition that is much more based on knowledge and learning than before (Lundvall and Borrás, 1997). It has been widely accepted that only "learning" economies are successful in being innovative and thus competitive in the world economy. However, it is important to mention that the globalization trend, together with the fast development and wide use of information and communication technologies, has affected the innovative process. Lundvall and Borrás (1997) have identified that: due to accelerated speed of technological change; firms are forced to launch a new product much faster, there is an increasing trend for inter-firm collaborations and industrial networks, thereby it has become important for firms to rapidly transform the new signals received from the exterior environment into action inside the firm; and due to the increasing reliance on advances in scientific knowledge for major technological opportunities, the collaboration for firms with knowledge production centers has increasingly become important.

Researchers working on science and technology policies agree that the effects of globalization and rapid technological developments and transformation in the world economy have increased the importance of the concept of National Innovation System.

2.2. Defining the "Learning Economy"

Learning economy is defined as the acquisition of competences and skills that make up a learning individual or an organization. It is important to make the distinction between information and knowledge in the current information society. The distinction between tacit and explicit knowledge is important, since tacitness implies that it is not possible to separate the knowledge from its carrier (either an individual or an organization). Tacit knowledge can be obtained only by hiring skilled people or through merging with other organizations. It cannot be transferred and sold separately in the market. In the learning economy, where the pace of change is high, tacit elements remain at the core of individual as well as collective knowledge. (Johnson and Lundvall, 2000).

One alternative concept to the ‘learning economy’ is the ‘knowledge-based economy’ (OECD, 1996a). The most fundamental reason for preferring the ‘learning economy’ as the key concept is that it emphasizes the high rate of economic, social and technical change that continuously underlies the formation and destruction of specialized knowledge. It makes clear that, what really matters for economic performance is the ability to learn (and forget) rather than the stock of knowledge (Johnson and Lundvall, 2000).

In recent years the interconnections between geographically different parts of the world have considerably increased and this has also multiplied the learning opportunities. However, globalization is an uneven and ongoing process. In some areas such as markets for financial assets it has developed very far while in others, it remains as being more directly related to competence building and innovation, and thus national borders still remain crucial (Iammarino and Archibugi, 2000). Globalization process neither does provide advantages to all social groups and regions, nor does it automatically reduce disparities. While some parts of the economy are at the core of the current trends, others have been marginalized. We have therefore preferred to refer to a ‘globalizing’ rather than to a ‘global’ economy to stress that the current state of the world remains far from one characterized by a truly global economy and society.

It is important to emphasize how the ‘learning economy’ and the ‘globalizing’ economy are strictly connected. The development of an integrated world economy has allowed acquiring information, expertise and technology at a faster pace and often at lower costs than in the past. In other words, ICT’s have acted as the material devices to allow globalization to occur (Archibugi and Lundvall, 2001).

2.3. Why “Learning Economy” is Important for Developing Countries

The learning economy is not a high-technology economy. One way of characterizing the new context of intense competition and rapid change is to define it as a ‘learning economy’ (Lundvall and Johnson, 1994; Lundvall, 1996). Rapid change implies a need for rapid learning and those involved in rapid learning impose a change on the environment and on other people.

A learning economy is an economy in which learning is the key factor for the economic success of individuals, firms, regions and national economies. "Learning" refers to building new competencies and establishing new skills, simply just to "getting access to information" (OECD, 2000), such that learning economy is not necessarily a hi-tech economy, which takes place in all parts of the economy. Low-income countries and regions are as strongly affected by the learning economy and experience the need for competence building even more strongly than the metropolitans (Lundvall and Borrás, 1997).

2.4. The Importance of Social Capital in the Learning Economy

Woolcock (1998) has criticized and elaborated the concept of "learning economy" so that it can be used to analyze economic development. At the micro level, he pointed to the need to combine strong internal cohesion (integration) with openness to the outer world. A densely networked but closed community will soon experience limits for further development. At the macro level, he introduced the role of the state as a factor having either positive or negative role in relation to economic development (Johnson and Lundvall, 2000).

Social capital is a key element in the learning economy. It also has implications for development strategies in low-income countries (training government officials so that they become self-confident and incorruptible without becoming an isolated caste with little understanding for the problems of farmers, workers and business may be fundamental for creating for a developmental state). To encourage programs where local collaboration is strengthened but at the same time linked to the wider community, may be another key ingredient in the innovation policy (Lundvall, 2001).

2.5. The Emergence of the National Innovation Systems (NIS) Concept

The concept of National Innovation Systems (NIS) has been widely acknowledged and extensively used by economists and policymakers since 1990s. NIS has been continued to be of great importance for nations in developing science and technology policies. In the most general sense, the concept can be described as a national system comprising all elements and their interactions, which contribute to enhancement of innovation. This chapter introduces the concept of NIS, defining its components separately. The core elements of the concept and effects of globalization on national innovation systems are discussed. Finally, the importance of the concept with regard to 'learning economy' is elaborated.

The concept of NIS was first proposed by the so called neo-Schumpeterian/ evolutionary economists Christopher Freeman, Bengt-Åke Lundvall, Richard Nelson and Nathan Rosenberg in the 1980s. But, the concept of NIS was not new and these economists were inspired by the work "The National System of Political Economy" written by Friedrich List (1841, cited in Lundvall 1992). List, who had prepared this work during the time when the Industrial Revolution was flourishing in England and Germany was trying to catch-up with the developments in England, was aware that science, technology and skills played a significant role in the growth of nations and criticized the classical economists for not giving sufficient attention to these elements. He also proposed that intangible investment was an important as tangible investment. In short, he anticipated some of the most important aspects of the national innovation system (Lundvall, 1992).

During the 1980s, a group of neo-Schumpeterian/evolutionary theorists became aware that the dominating neoclassical economic theory was not capable of bringing forward the important aspects (like innovation and technological change) leading to economic growth (Lundvall, 1992). By accepting that "innovation" is the main drive for economic growth, these theorists elaborated Schumpeter's theoretical work on innovation, made important advances in innovation theory and developed the concept of NIS. An important starting point leading to this new approach was the work done by Nelson and Winter (1982).

The 'system of innovation' approach has developed and evolved originally from 'national system of innovation' (NIS) presented by Freeman (1987; 1988; 1995), Lundvall (1988; 1992) and Nelson and Rosenberg (1993). Freeman (1987) was among the first to use the concept to describe and interpret the performance of Japan over the post-war period. He identified a number of vital and distinctive elements in its national system of innovation to which could be attributed its success in terms of innovation and economic growth (Freeman, 1988, p.338). Carlson (1995) has developed the 'technological systems' approach, indicating that systems can be specific to particular technology fields or sectors (Carlson, 1995).

A classical theme in industrial economics is the possible trade-off between static efficiency and innovative capability. This discussion has its roots in Schumpeter's late contributions on big firms as being the most efficient in promoting science-based innovation. The idea that a high degree of industrial concentration tends to promote innovation was stated most strongly by Galbraith (Galbraith, 1967). The debate was later followed up by a multitude of empirical tests of R&D-intensity in firms of different size. The main result of these studies was that R&D intensity was growing with size until a threshold limit where the intensity started to fall again.

Recent contributions in this field can be grouped into two categories: The first is the Schumpeterian-oriented economists (such as Dosi, Nelson and Winter) who have insisted on the fact that there is a two-way relationship between innovation and competition. They typically worked with models where both innovative activities and industrial structures are treated as endogenous variables and as outcomes of evolutionary processes (Nelson and Winter, 1982; Dosi, 1984).

On the other hand, Geroski and other economists with neo-classical roots have tried to test directly if innovations were positively or negatively correlated with high degrees of market control. Geroski (1995) demonstrated that the intensity of competition on average had a positive impact on innovation but that technological opportunity was a more important factor than the competition regime. Actually, his analysis confirmed that the relationship between innovation and competition went both ways (Geroski, 1995).

Innovation is not the only important aspect of dynamic economic performance. Among economists that are close to the realities of business, it has been generally accepted that the last decade has given a competitive advantage to firms with a high degree of functional flexibility enabling them to react and adapt promptly in an increasingly turbulent environment. It is important to note that the emphasis is on change. Actually, it might be argued that an analysis, which focuses on changes in the intensity of competition, is more relevant for policy issues than an analysis comparing the intensity of competition across sectors.

The neo-Schumpeterian/evolutionary theorists have outlined the major weaknesses of neoclassical approach in explaining and bringing forward today's economic aspects as follows;

> Due to its static, equilibrium oriented nature, based on endless elaboration and refinement of assumptions; the neo-classical theory fails to address some of the crucial problems regarding the long-term behavior of the system, such as technical and institutional change. As a consequence, inadequate attention is given to social learning processes, particularly technological accumulation and the institutions affecting these processes (Dosi et al., 1988).

Although accepting the importance of technical and institutional change, the neo-classical approach separated economics from these crucially important processes of change (characterized by the flow of new knowledge, inventions and innovations) considering them as "residual factors" or "exogenous shocks", even though they were at one time subsumed within the general framework of classical political economy (Dosi *et al.* 1988, Freeman& Soete, 1991) attribute this to the fact that economists were the victims of their own assumptions and commitment to accepted systems of thought.

Another weakness of the neo-classical approach is that the technological development process is seen as a linear process from basic scientific research at one end (invention), all through product development and production (innovation), to marketing at the other end (diffusion); and that firms are seen as single actors without any interaction with the outside world. However, the technological innovation process evolves by the dense interaction between firms, universities, public and private R&D institutes, banks and other financial services. Therefore, the understanding of the process of technological innovation requires a "system" approach (Soete and ter Weel, 1999).

In short, the concept of the neoclassical approach remains too narrow in understanding the new economy, where networking, cooperation and learning by interacting are necessary elements for economic growth and competitiveness. Whereas, the neo-Schumpeterian/evolutionary approach puts technological innovation and learning processes at the center of the analysis of economic development processes. It concentrates on how firms innovate and adapt to innovations.

In the history of economy, Schumpeter was the first twentieth century economist to become aware of the role of innovation in economic growth. According to him, in order to be competitive, firms had to be innovative and those who could not adapt to these challenges would not survive. Schumpeter named this process as a process of "creative destruction". Since this process is also very similar to how Darwin explained "the origins of life" in his evolutionary theory ("mutation" and "natural selection") this approach has been termed as "evolutionary".

By the end of the 1980s, the neo-Schumpeterian/evolutionary economists who became aware that innovation and interactive learning were the main drivers for economic growth and that a systems approach was needed in order to examine the features of a national economy which most affect success or failure in innovation, proposed and later developed the concept, or as Lundvall (1992) puts it "focusing device" of national innovation systems (Lundvall, 1992).

2.5.1. National System of Innovation

There are two approaches regarding the NIS-concept: one is developed by Freeman (1987) and the second is 'Aalborg-version' of the NIS by Lundvall (1985; 1992). Especially, the latter takes as its starting point the fact that important parts of the knowledge-base are tacit and proceeds from routine-based learning-by-doing, -using and -interacting and not only from search activities related to science and technology.

The concept of national system of innovation goes back to Friedrich List who criticized what he labeled as 'the cosmopolitan' approach of Adam Smith as too focused on competition and resource allocation to the point where the development of productive forces were neglected. The analysis of national systems developed by List took into account a wide set of national institutions including those engaged in education and training as well infrastructures such as networks for transportation of people and commodities (Freeman, 1995).

The US-approach (Nelson, 1988) linked to the concept mainly to hi tech-industries and put the interaction between firms, the university system and national technology policy at the center of analysis. Freeman (1987) introduced a broader perspective that took into account national specificities in the organization of firms. The Aaolborg approach (Lundvall 1985; Andersen and Lundvall, 1988) was inspired by the analysis of national production system pursued by the French structuralist school in Grenoble. It looked at national systems of innovation as rooted in the production system and it also emphasized the institutional dimension, where institutions where defined theoretically either as norms and rules or as materialized in the form of organizations (Johnson, 1988). Porter (1990) brought in regimes of competition as important dimensions of national systems.

When the concept of 'national system of innovation' first appeared in the literature (Lundvall, 1985; Freeman, 1987), it reflected new developments in innovation research. The most fundamental new insight of innovation studies in the 1980s was innovation was accepted as being an interactive process where agent and organizations communicate, cooperate and establish long-term relationships. It was realized that 'un-traded inter-dependencies' played a key role in explaining the rate and direction of innovation. The concept of "National System of Innovation" can be regarded as a tool for analyzing economic development and economic growth.

2.5.2. The Nature of Innovation Process

It has also been emphasized that the innovation process is an interactive process of a social nature (Lundvall, 1997). Interaction takes place, at least, at three different levels:

- Interaction between different steps of innovation process,
- Interaction between organizations, and
- Interaction between different departments of the same firm.

At each of these levels, agents and individuals communicate and cooperate. They need to develop a common language and modes of interpretation and, above all, trust in order to overcome some of the uncertainties characterizing the innovation process (Lazaric and Lorenz, 1998). This is one reason why the learning economy cannot function without a minimum of social cohesion.

Lundvall and Borrás (1997) identify the nature of the innovation process affected by four major trends of the globalizing context:

Acceleration: In general terms, technological change has speeded up substantially over the last few decades. This is mainly illustrated by the fact that the time required to launch a new high-tech product has been significantly reduced. The process from knowledge production to commercialization is much shorter today. The fast development and wide use of ICT (Information Communication Technologies) has certainly played a key role in bringing about this change.

Inter-Firm Collaborations and Industrial Networks: New products are increasingly integrating different technologies, and technologies are increasingly based on different scientific disciplines. This is also reflected in the costs of developing new products and systems, which have grown. Short product life cycles require a rapid entrance into all major markets around the world. Most firms do not have the capability or the resources to undertake such initiatives, and this is the main reason for the expansion of collaborative schemes for pre-competitive research and the growing importance of industrial networks.

Functional Integration and Networking Inside Firms: Rapid adaptation and innovation gives an advantage to the functionally integrated firms. Rapid transformation of new signals from the exterior environment into action inside the firm can take place only if departments collaborate closely and employees engage in horizontal-communications within the firm. Flexibility, interdisciplinary- and cross-fertilization of ideas at the managerial and laboratory levels within the firm are now important keys for success.

Collaboration with Knowledge Production Centers: The increasing reliance on advances in scientific knowledge for new technological opportunities has been an important stimulus for firms to collaborate with scientific centers like public and private laboratories, universities and other basic and applied research centers.[1]

[1] Summarized from Lundvall B-Å. and Borrás S. (1997)

2.5.3. Innovation and Competitiveness

Innovation is a major driving force of change because it affects the competitive position in the economy. An alternative approach to the concept is that “Innovation is the process through which productive resources are developed and utilized to generate higher and/lower cost products than had previously been available”. The other feature of the neo-Schumpeterian approach is the perception of economic change as an evolutionary process and the economy as an evolutionary system. An economy is understood to be a population of firms, or other economic agents, which represents the variation of the system. Members of the population are continuously interacting with each other and with the environment, thus constantly influencing the direction of change as well as the definition and redefinition of the environment, represented by the social and institutional structure governing the interaction. In such a system, both what is learned and the processes of learning are cumulative which introduces the quality of path-dependency to the economy.

Furthermore, firms are operating in the market, which acts as the selection mechanism necessary to secure the stability of the economy. In this view, the reason why innovation is of such crucial importance to economic growth is that being innovative, a firm will attain a temporary monopoly that makes the firm more profitable than its competitors, or more competitive, i.e., the ability to innovate signifies the fitness of the individual firm in this evolutionary process of economic survival. By including innovation into the economic process, knowledge is no longer solely regarded as a public good and Schumpeterian approach thus provides an incentive for the investment in knowledge enhancing activities in the economy. Eventually other firms will reproduce the innovation or surpass it, to secure variation at the system, and sustained competitiveness will depend on the firm’s constant ability to innovate (Nelson and Winter, 1982). This phenomenon, which has become known as “Schumpeterian competition”, or quality competition, links the concept of innovation with competitiveness of firms in a way which finally seems to contribute to an endogenous explanation of economic growth.

2.6. Policy Consideration in the "Learning Economy"

2.6.1. The Model

Lundvall and Borrás (1997) proposes that the starting point is a simple model as seen as on Figure 2.1, where it is shown that the transformation pressure can be linked to the economic structure at the level of the whole economy in such a way that the adjustment and innovation process at the level of the firm and knowledge organizations may affect the capability to cope with an increased transformation pressure in at least three different ways. First it may involve a simple sharing of risks, second it may enhance the functional flexibility of the firm and third, it may make it possible to speed up innovation.

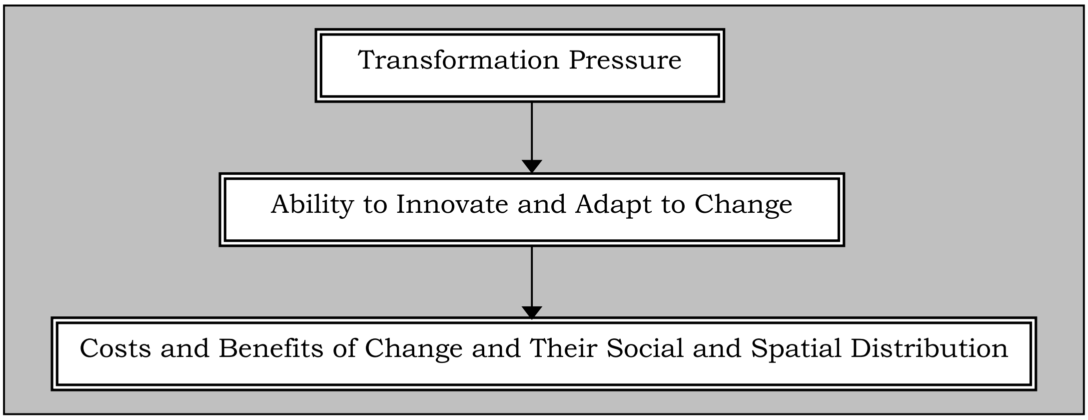

Figure 2.1. The Basic Model - From Macro to Micro and Back to Macro (Lundvall and Borras, 1997).

A stronger emphasis on functional flexibility and innovative capacity will increase the demand for general personal skills having to do with cooperation and communication and it will also imply a stronger need for workers to take on an individual responsibility in the work process.

Technical change and product development will increase the demand for specific skills and for new types of skills. A speed up of the innovation process will increase the rate of creative destruction of skills and competences. This will increase the need for life-long learning in the whole economy and at the level of the firm to move toward a 'learning organization'.

Experiencing from the Danish 'DISCO' Project

The DISCO-project (Danish Innovation System in Comparative perspective – financed by the Ministry of Industry and carried out at the University of Aalborg by the IKE Group (an acronym for Innovation, Knowledge and Economic dynamics, Department of Business Studies at Aalborg Universtiy) is the most ambitious effort so far to map a national system of innovation in a broader sense. It includes analysis of organizational forms at the firm level, relations between firms, the overall production structure, institutional structure, and policy perspectives. Denmark is a small and open economy dominated by small- and medium-sized firms. It is important to note that most of the new technologies will be developed abroad and then adopted and adjusted to local needs.

The Disco-project has been divided into four distinct modules, each focusing on a specific level of the innovation system: Technical change, organizational change and human resources development within firms (Based on national survey, on Nordic country comparative survey, with case studies and linking survey results to statistics on labor market dynamics).

Concluding from the Disco-Project, an increased transformation pressure, registered by firms as an intensification of competition, has had multi-dimensional effect on the economy. Survey data indicate that the increased transformation pressure has increased the skill requirements in firms and that the increased competition is the most important factor behind this change. These survey results give the below mentioned policy considerations;

First, they give a new perspective on the role of competition in relation to innovation. Data indicate that incremental innovation and organizational change are affected by the competition in product markets.

Second, a fundamental contradiction is pointed in the learning economy. There is a tendency toward increased polarization, which may undermine the social cohesion necessary to promote learning and sharing of responsibility.

One way to respond this contradiction is to regulate the transformation pressure (through competition, trade and macroeconomic policies). The other way is to focus redistribution policies on the capability to learn and give special priority to enhancing the learning capability of unskilled workers.

The analysis shows that in this specific case organizational change is promoted by an intensification of competition and that resulting trend is the one towards a learning organization where there is less room for routine work and rigid interdivisional splits. One of the outcomes is a stronger demand for skilled labor and for continuous upgrading of human resources.

For the firms that remain sheltered from competition, it is not self-evident that a move toward a flexible and innovative form of organization is attractive or necessary.

There is no reason for why the firms which have adopted a flexible and innovative organization should be more successful in terms of their private rate of return since firms following more traditional organizational trajectories on average are those least exposed to competition.

There is also no reason to believe that globalization and the intensification of competition will not continue in the future[2].

2.6.2. Building Transformation Pressure

According to Lundvall and Borrás (1997), one of the most fundamental factors affecting the transformation pressure is technical change. New technology in the form of new products and new processes offers new opportunities as well as new threats for the single firm. A second major factor is the competition regime. New entrant into markets and extensions of markets bringing in new competitors located elsewhere are factors that increase the transformation pressure.

Governance regimes – the role of ownership and finance in managing of the firms – affect the intensity and the direction of the transformation pressure. Finally, the macroeconomic stance affects the transformation pressure. For instance, a situation characterized by deflationary policies and over-evaluated currency rate implies strong transformation pressure, as do aggressive trade union wage policies.

According to Ludvall and Borrás (1997), firms may react to an increasing transformation pressure in a number of ways. They may go on as before without implementing any kind of change. They might try to reduce the 'fat' of the organization. That might include strategies of 'quantitative flexibility', i.e., firing some of the personnel. Sometimes such a strategy will succeed and sometimes it will lead to a close-down of the firm and its activities.

Second alternative is to adapt to the increasing pressure by moving resources from less promising to more promising activities. The capability to do so will reflect the degree of 'functional flexibility' of the firm. A related even more strategic form for behavior is for the firm to engage in organizational change aiming at increasing the functional flexibility.

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[2] DISCO Project summarized from Lundvall and Nielsen (1999) and Lundvall and Christensen (1999).

A third alternative is to introduce more efficient process technology and to introduce organizational change aiming at increasing the efficiency in the use of new technology.

A fourth alternative is to introduce product and service innovations that make it possible to side step and reduce the intensity of competition in product markets.

A fifth alternative is to look for a new positioning with industrial networks. Establishing closer relationships with customers and suppliers and with knowledge organizations may affect the capability to cope with an increased transformation pressure in at least three different ways. First, it may involve a simple sharing of risks; second, it may enhance the functional flexibility of the firm and; third, it may make it possible to speed up innovation (Lundvall and Borrás, 1997).

2.6.3. Ability to Innovate and Adapt to Change

Lundvall and Borrás (1997) point out that "a key to successful innovation is to have a strong knowledge base including an R&D (Research and Development) capacity and well-trained labor force". But as indicated by the concept 'innovation system'; many different agents, organizations, institutions and policies combine to determine the ability to innovate (Lundvall, 1992). Adaptation to change may take many forms and this is the subject of the ongoing debates on economic policy. Flexible labor markets may be at the core of adaptation in some innovation systems while others adapt more through functional flexibility within organizations. The creation of new firms may be a key to adaptability and innovation in some systems while others rely more on innovating and reorienting the activities of existing firms below the focus will be on the introduction of learning organizations and on network formation as a response to a growing transformation pressure. The most basic principle is to create a learning economy that cope with rapid change and be successful in developing new products and services. This involves policies aimed at including (Lundvall and Borrás, 1997);

- Human resources development,
- New forms of organization,
- Building innovative networks,
- A new role for the service sector, and
- Integrating research institutions into innovation system.

2.6.4. Costs and Benefits of Change and Their Social and Spatial Distribution

According to Lundvall and Borrás (1997), the different forms of adaptability characterizing an innovation system will distribute the costs and benefits differently. Firms integrated in successful and dynamic networks may prosper when the transformation pressure increases while firms operating in formerly protected areas but now becoming exposed to new competitors will have to fight for their survival.

2.7. Concluding Remarks

Since learning takes place in an environment of production, consumption and marketing activities, and is an essentially interactive process, the connection between learning and innovation becomes crucial. Interactivity in learning refers to the fact that the rate and direction of innovative activities are influenced by economic structure and institutional set-up. Similarly, technical change, competition regimes, macroeconomic stance create transformation pressure for firms to compete with rapid change and be successful in developing new products and services. Learning Economy, dealing with all these issues, brings about new policies seeking for human resource development, new forms of organizations, building innovative networks, a new role of the service sector and integrating research institutions into innovation systems.

CHAPTER 3

LEARNING PROCESS AND LEARNING ORGANIZATIONS

This chapter explains in detail the dynamics of learning process and learning organizations, and the relationship between innovation and learning which are the drivers of the ‘learning economy’.

3.1. Knowledge and Economic Growth

As discussed in the early chapters, knowledge is the central element of the emergent mode of production that has been called the “knowledge-based” or “learning” economy. When viewed from this perspective, knowledge is a crucial input to competitive economic activity and the generation of economic growth. Knowledge may take the form of technological or organizational advances. Such advances in knowledge may be obtained in a variety of ways: by organized research carried out in universities and research institutes; by activities in R&D divisions of firms; by individual researcher; and by simple experience and observation of the product process. In all cases, what is involved is the creation of new knowledge. In general terms, it has come to be increasingly recognized that long-term economic growth is dependent on investment in these types of knowledge production and diffusion. However, knowledge in itself does not contribute to economic growth. Crucially, it has to be incorporated into the production of goods and services. Advances in technological and organizational knowledge have to be absorbed effectively by enterprises and applied within the production process and the organization of work more widely. Therefore, knowledge in the form of innovations may be regarded as an output of learning and economic activities.

The innovative capability of organizations which in turn to a large extent determines their competitiveness within the new learning economy. Especially in areas where factor costs (especially wage costs) are relatively high, long-term, sustainable competitiveness has come to be increasingly related to the ability of firms to improve their performance by means of a continuous process of innovation. (Lundvall, 2001).

3.2. Learning Process

3.2.1. Tacit and Codified Knowledge

One way to understand how knowledge is involved in the process of innovation is by using Michael Polanyi's distinction between tacit and codified knowledge (Polanyi, 1966). In Polanyi's words; Tacit Knowledge refers to intuitive knowledge that is based on a persons many experiences and cannot easily be put into words. Codification of knowledge implies that knowledge is transformed into 'information', which can be easily transmitted through information infrastructure. It is a process of reduction and conversion, which especially facilitates the transmission, verification, storage and reproduction of knowledge. As explained by Foray and Lundvall (1996), codified knowledge is typically expressed in a format that is compact and standardized to facilitate and reduce the cost of such operations. Codified knowledge can normally be transferred over long distances and across organizational boundaries (Foray and Lundvall, 1996).

In contrast to codified knowledge, tacit knowledge is the knowledge, which cannot be easily transferred because it has not been stated in an explicit form. One important type of tacit knowledge is "skill". The skilled person follows rules not known as such even by the person following them (Polanyi, 1958). Another important kind of tacit knowledge is implicit but shared beliefs and modes of interpretation that intelligent communication possible. According to Polanyi (1958), the only way to transfer this kind of knowledge is through a specific kind of social interaction similar to the apprenticeship relationship. This implies that it cannot be sold and bought in the marketplace and that its transfer is extremely sensitive to social context.

The fast development of information and communication technologies gives a strong impetus to the process of codification by increasing the economic value of codified knowledge. Most knowledge, which can be codified and reduced to information, can be transmitted over long distances at very limited costs. Certain stages in the innovation process are characterized by the use of information technology and by partial codification. Testing and designing new products and processes can now be done with the help of information technologies.

Codification is an important process for economic activity and development for four main reasons (Foray and Lundvall, 1996). Firstly, codification reduces some of the costs of the process of knowledge acquisition and technology dissemination. Secondly, through codification, knowledge is acquiring more and more the properties of a commodity. This implies that market transactions are facilitated by codification as it reduces the uncertainties and information asymmetries in transaction involving knowledge. Thirdly, codification facilitates knowledge externalization and allows firms to acquire more knowledge than previously at a given cost. Finally, codification helps directly to speed up knowledge creation, innovation and economic change.

In a company, there are various kinds of knowledge, which altogether constitute the knowledge-base of the firm. The company knowledge-base is a composition of knowledge that exists on different levels of aggregation: company-specific, generic, or industry-specific, and universal, and involves both individual and collective knowledge, as well as various degrees of tacit and explicit knowledge (Smith, 1998). Because new knowledge is continually created through the interaction between tacit and codified knowledge, knowledge bases of firms and industries are in constant evolution. Firms learn, and by doing so, they increase their knowledge base by incorporating new knowledge, which often implies that some of the old knowledge is no longer applicable. This necessitates an additional process of "creative forgetting" (Lundvall and Johnson, 1994). The two processes of learning and forgetting make up the concept of interactive learning, which includes imitation, searching, exploring and any other activity that will lead to the increase of economically significant knowledge (Johnson, 1992; Nelson and Rosenberg, 1993).

The other characteristic of learning can be regarded as cumulative; i.e., what one learns depends on what one already knows and therefore the production structure of the economy affects its learning processes. The production structure of an economy consists of only a tangible structure of buildings, equipment, etc., but also of a connected intangible structure of knowledge accumulated through production experiences. Furthermore, different industries have different technological opportunities and bottlenecks, i.e., the learning possibilities are quite different in different lines of production (Lundvall, 1996).

Johnson (1992) claims that the role of forgetting is another important factor in the economic process. The enormous power of routines and habits of thought in the economy constitutes a permanent risk for blocking potentially fertile learning process. Sometimes 'creative destruction of knowledge' is necessary before new knowledge can get a foothold. Departments, organizations and firms have to be closed down and people have to move on to new activities and so on. Thus, the learning economy is also a "forgetting economy". It has to develop methods and institutions and channel resources to support 'creative forgetting'. Forgetting is not only a nuisance and a cost, but is also an essential integrated process (Johnson, 1992). The relationship between learning, Growth of knowledge and innovation is shown in Figure 3.1.

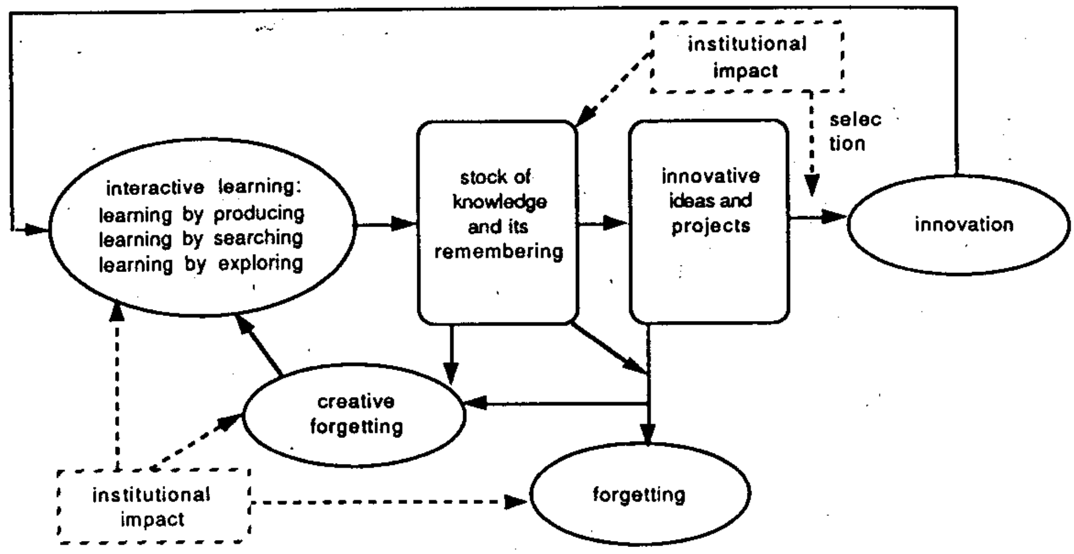

Figure 3.1. The Relationship Between Learning, Growth of Knowledge and Innovation (Johnson, 1992)

3.2.2. Direct and Indirect Learning

Gregersen and Johnson (1996) examined learning under two types; direct and indirect learning. Direct learning can be defined as such an organized process, i.e., some parts of the economy, for example, universities, research institutes, and R&D departments, are organized with the creation and utilization of new knowledge in mind. The other type of learning, indirect learning, can be defined as learning going on more or less as unintended by-products of normal activities such as procurement, production, and marketing.(Gregersen and Johnson, 1996).

Furthermore, Gregersen and Johnson (1996) claimed about other distinctions between direct and indirect learning. In literature, terms like learning by doing, learning by using, learning by searching, etc., have become quite common indicating that learning is a widespread and diversified phenomenon. One common characteristic of almost all learning processes is that they are interactive and dependant on the ability to combine and recombine different pieces of knowledge into something new. Interactive learning is the most common type of learning and the dominant source of innovation (Gregersen and Johnson, 1996).

3.2.3. Defining Individual and Organizational Learning

Innovation processes embody different forms of knowledge and learning. Individual learning refers to the acquisition of information, knowledge, understanding and skills by people, through participations in some form of education and training, whether formal or informal. Individual learning involves the dissemination of existing knowledge, and also the creation of new knowledge through R&D. The result of individual learning is the stock of human capital. In the learning economy, the value and importance of human capital is increasing (Lundvall, 2001).

As seen in Figure 3.2, individual learning and organizational learning are viewed as the key "inputs" to the "learning process model" underpinning the crucial process of innovation. However, both are, to some extent, dependent upon the level and the nature of the institutions (or form of social capital) in themselves. Economic competitiveness (and the growth) is a key 'output' of the system. Equally, social inclusion is necessary as a further 'output', if the system is to be sustained in the long term (Lundvall, 2001).

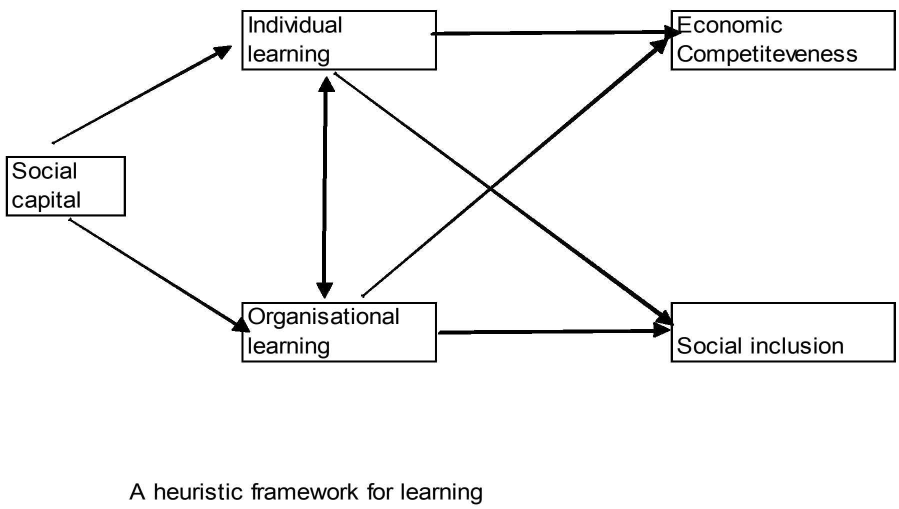

Figure 3.2. Individual and Organizational Learning (Lundvall, 2001)

According to Nonaka and Takeuchi (1995), organizational-learning process takes place within an expanding "community interaction" which crosses intra-and inter-organizational levels and boundaries. Firms can appropriate existing knowledge from outside or create new knowledge either inside the firm or with interaction and collaboration with other organizations. Organizational learning involves the creation of new knowledge to a much greater extent than individual learning. It is the interactive nature of organizational learning (Lundvall, 2001). Table 3.1 shows the categories of learning where organizational learning depends on individual learning and builds upon it.

Table 3.1. Categories of Learning (Lundvall, 2001)

	Dissemination of Existing Knowledge	**Creation of New Knowledge**
Individual Learning	e.g. schooling vocational training, "learning-by-doing"	e.g. university-based research by PhD student; learning-by-doing in the workplace
Organizational Learning	e.g. building data bases, creation of routines and manuals; appropriation of technological licenses from other firms; recruitment of highly qualified staff by firms	e.g. R&D in universities by research groups; R&D within firms; collaborative R&D between firms and research institutes

3.2.3.1. Individual Learning

Individual learning is associated with formal education in schools, colleges and universities and with formal vocational preparation. Individual learning is concerned with the dissemination of existing knowledge. The forms of knowledge, to which Lundvall and Johnson (1994) refer, are known as "know-what" and "know-why". "Know-what" can be defined as knowledge about "facts" and conventionally called information that it may be codified and communicated. "Know-why" refers to knowledge about principles about theories in relation to the organization and functioning of the natural world that this form of knowledge may be codified and communicated quite readily (Lundvall, 2001).

The majority of technological process innovations and most product innovations do not occur without access to knowledge of these kinds. The other form of individual learning, i.e., learning-by doing, is a key process of knowledge production and dissemination. This type of learning is generated in the course of normal activity (Myers and Davids, 1993 cited in Lundvall, 2001). The experience participating in the production process that refers to "know-how" is described as "practical knowledge" in the form of skills and skilful performance (Lundvall and Johnson, 1994). "Know-how" or "practical knowledge" forms a significant input into innovation process. Both the production and dissemination of "know-how" is facilitated by what has been termed as "learning by interaction".

3.2.3.2. Organizational Learning

"Learning-by-interaction" is also regarded as the key to achieve effective organizational learning. Organizational learning depends not only on generating high rates of "learning-by-interaction" inside the organization, but also between organizations. With the development of learning economy, organizations need to cooperate in order to share the specific forms of knowledge. This sharing of knowledge takes a variety of forms that it may involve the acquisition knowledge from other organizations such as firms, universities, R&D institutes, etc. Organizations collaborate with others to produce new knowledge-innovations, such that firms and research institutes are increasingly forming R&D consortia with the objective of generating new knowledge. These forms of organizational "learning-by-interaction" are crucial to the development of innovative capability.

3.3. Innovation and Learning

Relationship between Innovation and Learning is an important part of the thesis and this will be examined in Chapter 5 as a case study.

Innovations are understood as new creations, which have economic significance by virtue of their adoption within organizations. In this sense, therefore, they embody knowledge that is in demand. However, they do not constitute a homogenous category. Innovations can both create jobs and destroy them; they can both increase skill requirements and decrease them. Accordingly, the broad category of innovations may be divided into subcategories by means of the following taxonomy (see Figure 3.3) (Lundvall, 2001).

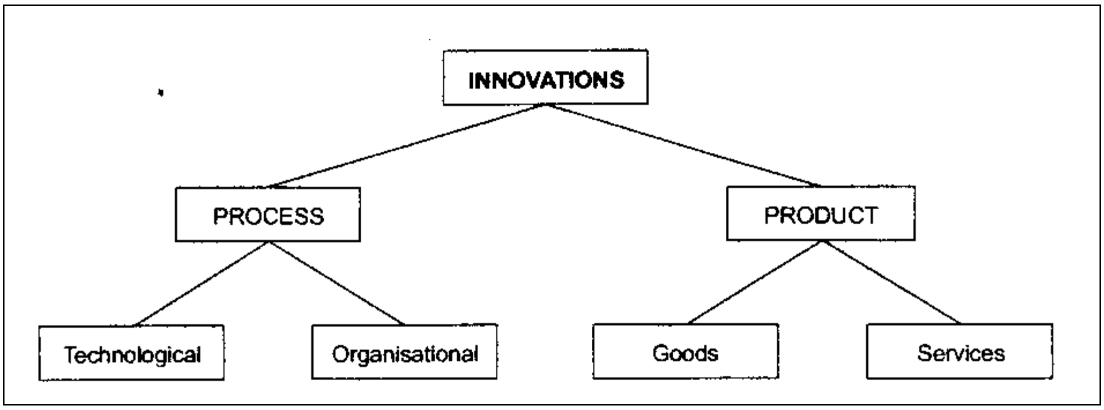

Figure 3.3. The Taxonomy for Innovations (Lundvall, 2001).

Process innovations are a matter of how things are produced; whilst product innovations are a matter of what is produced. Technological process innovations and product innovations in the form of goods generate material outcomes. Organizational process innovations and product innovations in services are intangibles. The relationship between product and process innovation are complex. Firstly, there is relationship between product and process innovations. The creation of a new product itself requires new process technologies. Secondly, there is a close relationship between technological and organizational process innovations. When a new technological process innovation is introduced, it is often also necessary to change the organization of work. Organizational innovations are frequently necessary to reap the productivity benefits of technological process innovations[3]. Only with the advent of the new economy in the mid-1990s has the organizational context begun to "catch-up" with the implications of these technological innovations. This is probably why there is more training and more employee participation in firms that implement new process technologies than in firms, which do not (Weber, 2000). Finally, there is obviously close relationship between new goods and new services. One example here is the relationship between a material mobile telephone system and the service of mobile phone calls. Whilst one innovation is entailed by the other, there remain analytical distinctions not only to facilitate understanding of the highly complex processes involved, but also to assist in the development of effective initiatives.

Innovation is defined as a process, which is the introduction into the economy of new knowledge or new combinations of old knowledge. The introduction and the dissemination of new knowledge is an integrated process and it is difficult to localize innovations as unique events in time and space. Innovations can be regarded as 'learning results' that it leads to new knowledge and entrepreneurs of different kinds use this knowledge to form innovative ideas and projects. There is always a lot of knowledge around which is not put to use in the economy and the ability to utilize existing knowledge is the crucial aspect of the learning economy. There are several reasons that constitute relevant environments for interactive learning and innovation (Gregersen and Johnson, 1996):

First, institutions and institutional change affect innovations. Without institutional adaptations and institutional innovations the process of technical change would be more restricted. Many of these institutional changes, which are necessary for the process of technical innovation, require regulation by the state. Intellectual property rights, standards, capital and labor market regulations, contract laws, etc. need to be developed or changed.

[3] One of the best-known examples is the "Solow paradox" where the productivity impact of the introduction of information technologies was smaller than expected.

Second, innovation leads to structural change, which means different rates of growth for different groups of people. This generates conflicts, which may restrict continual growth. Institutions reducing the conflicts generated by the combined process of growth and structural change are important parts of the environment for innovation and growth formed by the nation state.

Third, learning and innovation depend on an infrastructure, which requires regulation as well as investments by the government. Due to technical and organizational changes, classical fields of infrastructure, like transport and energy, may be of decreasing importance as state monopolies, but in areas as education, supply of information, technical standards, basic research, and so on, i.e. in the knowledge infrastructure, the importance of state activities is increasing.

Fourth, innovation driven economic growth is a process of continual transformation. The economy expands into materials, new sources of energy, new products, and it contracts from old ones. This requires a mobile labor force. People have to be ready to move from one occupational position to another may be several times in generation. This is not possible without the support of a system education and training, which provides both general purpose and learning skills and diversified specialization possibilities as the national educational systems supervised by the state has done for years.

Intense labor mobility between different social and occupational positions requires not only theoretical abilities and instrumental skills but also a kind of cultural homogenization. This is an important aspect of the system of education and training. The nation is often an expression of a common culture, which is supported by the political power of the state. This is the fifth aspect of the nation state as an environment for learning and innovation. The performance of an innovation system depends on effective communication and interaction between people with different skills and knowledge and thus on the nation state as an environment for such communication and interaction (Gregersen and Johnson, 1996).

Government policies have usually been aiming at the support of knowledge production (R&D support) rather than knowledge utilization. There has been a growing emphasis on the distribution and utilization of knowledge, for example through support of various technology service systems (Gregersen and Johnson, 1996).

Lundvall (2001) points out that effective learning and innovation is produced in functioning networks of firms and other organizations. Moreover, such networks need to encompass a variety of firms, producing a range of goods and services; organizations within the public sector, which provide research and educational services business support and other means of facilitating innovative economic activity; trade unions; as well as civic organizations, such as chambers of commerce and trade associations. It is important to acknowledge that the incentives to participate in networking activities vary substantially between them. Employees are required to participate in continuing individual learning processes, in order to sustain learning and innovation at the organizational level[4] (Lundvall, 2001).

Learning and innovation requires a careful balance to be held between the necessity of introducing new ideas and practices. Lundvall (2001), claims that:

> The development of effective learning and innovation requires that what have often been treated previously as separate policy areas (industrial policy, science and technology policy, education policy, and so forth) are brought together within a coherent framework of integration"(p.119).

The overall interrelations causing the link between learning (direct and indirect) and innovation are illustrated in Figure 3.4.

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[4] Lundvall (2001) examined the relationship between the developing regional system of innovation and the process of individual and organizational learning in "Cities and Regions in the New Learning Economy", and underlined ten policy principles for creating learning cities and region (see Appendix A).

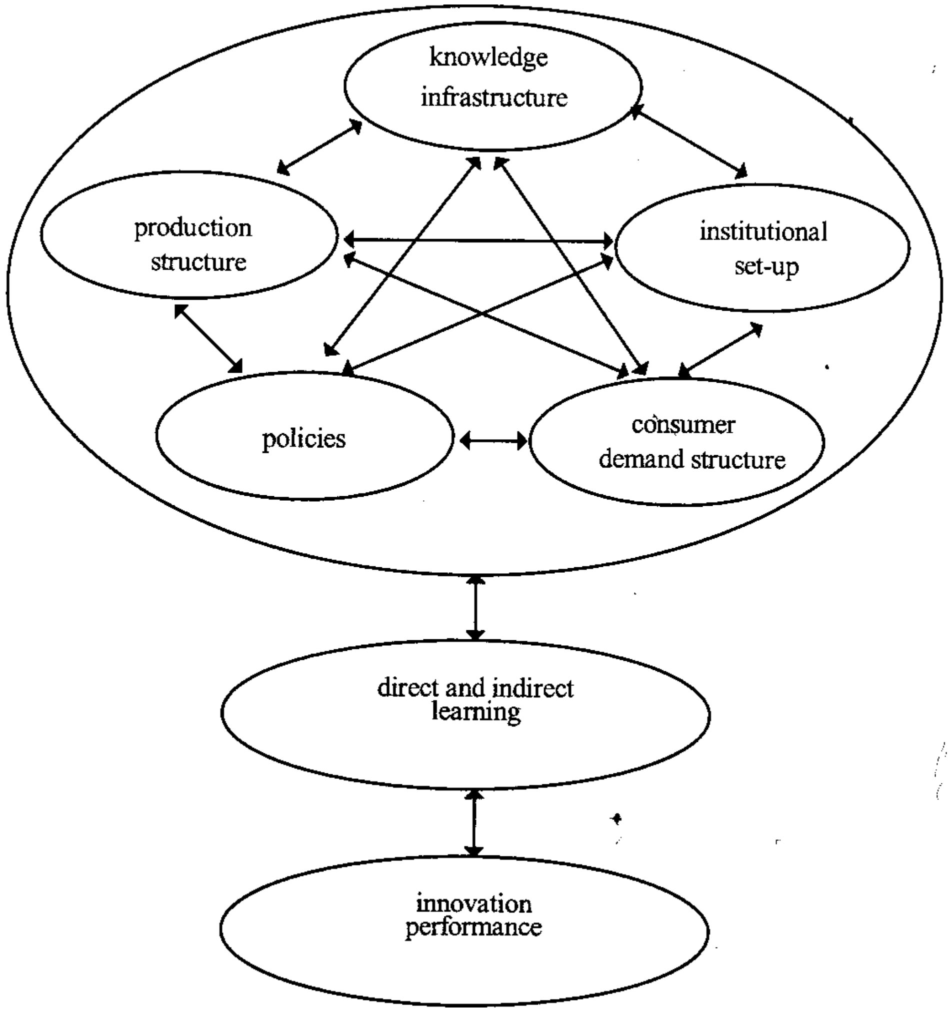

Figure 3.4. Main Factors Affecting Learning and Innovation (Gregersen and Johnson, 1996)

3.4. Learning and Change

Learning and change are closely related and the causality works both ways. On one hand, learning is an important and necessary input in the innovation process. On the other hand, change imposes learning on all agents affected by change. In this context, it is important to note that a significant and growing proportion of the labor force is designated to promote change while for the rest of the labor force change is imposed from outside (Lundvall and Ernst, 1996).

In a market economy, there is a strong incentive to create and exploit novelty. Producing the same thing in the same way is not very rewarding. Finding new and more efficient methods of production and introducing new and more attractive products into the market is necessary for survival in most competitive markets. Learning in connection with production and interaction with users is fundamental for the success in process and product innovation (Lundvall, 1985). Learning involves finding and defining the problems to be solved -to develop an agenda for problem solving- as well as forming the know-how helping agents to find the way to solve problems (Lundvall and Ernst, 1996).

Learning creates change and promotes innovation. According to Lundvall and Ernst (1996), when a competitor introduces a more efficient process or a more attractive product the pressure for change increases, and the consumers, when confronted with new products, also have to change their behavior. And change involves learning such that introducing a new machine, addressing a new market or organizing the firm differently than before puts everyone in a learning position.

In this sense, learning is a self-reinforcing process that reflects a peculiarity relating scarcity and knowledge. Knowledge is not a scarce resource in the traditional sense; using knowledge is, in economic terms, identical to imposing change and imposing change triggers further learning (Lundvall and Ernst, 1996).

3.5. System of Innovation

The system of innovation emphasizes upon patterns of interactive learning that provides the foundation for systematic approaches to the analysis of innovation processes. From this perspective, system of innovation is conceptualized in terms of the organizations involved in the development, diffusion and use of innovations and their inter-relationships[5]. The learning made possible by interaction is central

[5] As is discussed in early chapters; for further information, see Freeman, 1987; Lundvall, 1992; Nelson, 1993; Edquist, 1997 (Lundvall, 2001).

for the firms that do not innovate in isolation, but in interaction with other organizational actors. As Lundvall (2001) says; for example, the long-term innovative performance of firms in science-based industries is strongly dependent upon the interactions between firms and universities and research institutes. Market competition, as well as the framework of existing rules in turn, shapes this interactive learning in between firms and other organizations. The system of innovation approach emphasizes that innovation is an endogenous part of the economy, and, in fact, constitutes an important determinant of economic change. Organizations with which innovating firms interact include other firms (suppliers, customers, and competitors) as well as R&D institutes and universities and organizations whose objectives are to facilitate learning processes. Such organizations constitute the actors of the innovation system; although the nature of their interaction is necessarily constrained by the characteristics of networks of organizations. Strongly hierarchical or vertical networks between, for example firms and their suppliers and sub-contractors, involve a radically different dynamics as compared to non-hierarchical or horizontal networks. Other networks may be based upon participation in civic association, such as chambers of commerce, professional associations (Cooke and Morgan, 1998).

3.5.1. Institutions

Learning is basically an interactive process, a social process that cannot be understood without regarding to its institutional and cultural context that gives some rules regarding into epistemological and methodological sphere (Johnson, 1992).

Institutions accepted as norms, habits and rules are deeply ingrained in society and they play a major role in determining how people relate to each other and how they learn and use their knowledge (Johnson, 1992). According to Lundvall (1997), there are four kinds of institutions in the context of learning and innovation: the *time horizon* of agents, the role of *trust*, the *actual mix of rationality* and the way *authority* is expressed. The focus on interactive learning also evokes the important role of economic structure and institutions in determining the rate and direction of innovative activities.

Nowadays, the almost generally accepted distinction between a more short-term perspective as characterizing corporate governance in Anglo-Saxon countries and a more long-term one in, for instance, Japanese investment decisions is one important example of how institutional differences have a decisive influence on the conduct and performance at the national level. This distinction is important not only for the allocation of finance, but also for other aspects of technical innovation. Certain technology areas will only be possible to develop into commercial success by agents who operate from a long-term perspective while others might be easier to exploit with a short-term horizon. The institution is not in any way ‘natural’ and even if it may have deep cultural and historical roots it will certainly be affected by developments in the economy. Sustained high rates of inflation will, for instance, undermine long-term perspectives and foster short term ones.

The second example relates to the role of trust in the economy. Trust is a multidimensional and complex concept. It refers to mutual expectations regarding consistency in behavior and full, truthful revelation of relevant information and to loyalty in difficult times. Trust can be very local or it can be extended to a wider set of actors. These dimensions of trust are crucial for interactive learning and innovation. The strength, the extension and the kind of trust embedding markets will affect transaction costs and it will determine to what degree interactive learning can take place in connection with the market relationship. Formal and legal arrangements around the market will reflect this tacit social dimension. To a certain degree, sophisticated legal institutions can overcome a lack of trust. At the level of the whole economy, trust is easier to undermine than to build anew. This is illustrated by the current state of the Russian economy where the historical development and the recent transformation to a ‘market economy’ have combined in wiping out any kind of socially rooted trust in economic affairs.

A third example is the 'rationality of agents' and this is perhaps the most fundamental institution when we confront the approach of standard economics. It is normally assumed that either instrumental or strategic rationality is the general rule for human behavior or at least that it dominates completely in determining human behavior in private economic sphere.

Finally, considering the importance of different forms of 'authority' in connection with industrial relation and organizations of different economic strength, it is evident that, as pointed out by Polanyi (1966), the learning of new skills will typically take place in the context of a master-apprenticeship relationship where a mixture of trust and authority is necessary.

Some of the contemporary efforts to analyze the complexities involved in the creation and diffusion of knowledge and technology into the economy are focused around the idea of innovation systems (Lundvall, 1992; Nelson, 1993; Edquist, 1997). The innovation system concept suggest that there exist certain structural influences (scientific, political, and socio-economic) within any nation state, or region, that help to define the pattern, nature and extent of knowledge accumulation and innovation within a given industry, region or nation. An innovation system is largely defined by the interactive relationships, taking place between economic actors within the institutional framework in which they are located. The institutional framework, or institutions, is further defined as the "*sets of common habits, routines, established practices, rules, or laws that regulate the interaction between individuals and groups*" (Edquist and Johnson, 1997).

3.5.1.1. Organizations, Firms and Institutions

According to Coriat and Weinstein (2002), the first dimension of cognitive coordination concerns the management of information and knowledge posing the problem of the conditions of organizational learning and building up firm's capabilities, and more specifically capacities to innovate. Furthermore, the pivotal question is to know what organizational patterns encourage learning processes and dynamic capabilities, and what the links are between modes of learning and modes of innovation (Coriat and Weinstein, 2002). The second dimension leads to the analysis of incentives and the modes of appropriation and distribution of surplus and/or rents that firms constitute from competitive advantages resulting from innovation.

Coriat and Weinstein (2002) claim that organizational approaches highlight two major questions to which any theory of innovation must give an answer:

First question: How can one understand both the diversity of organizational patterns and the existence of dominant modes of organization?

According to evolutionary theory, a key role should be attributed to the analysis of variety, since it largely determines technological and organizational dynamics. The diversity of organizations and firm patterns can be visualized under three dimensions; *Firm diversity*, within a same sector, linked to strategic specificities and path-dependencies that shape their trajectories and build up specific capabilities and routine systems (IBM versus Apple, for instance), *Sectorial diversity* linked to the characteristics of innovation regimes and selective environments that may induce specific sectorial trajectories (Dosi, *et al*., 1988; Malerba and Orsenigo, 1996), and *national diversity*, linked to the specificities of national innovation systems, specificities of national innovation systems, specialization profiles, institutional and cultural frameworks.

Second question: How can organizational patterns evolve to give birth to new principles and organizational systems?

One of the major aspects when dealing with the evolution of production processes is to know how organizational systems undergo transformations. Two major responses emerge from the organizational approach. The first is that the strength of organizational approaches is to allow for the recognition of the fact that firms "are the primary instruments in capitalist economies for the production and distribution of current goods and services and for the planning and allocation for future production and distribution" (Chandler, 1992). This implies that firms' structures and strategies are at the heart of innovation regimes. The second is that if the firm fulfills this key role in the dynamics of innovation, this is because it has the capacity to create, through its choice, 'organizational capabilities', as Chandler (1992) notes, which are the source of a competitive advantage, and, precisely for that reason, are destined to be diffused.

3.5.1.2. The Structure of Institutional Systems

The importance given to the coherence of organizational/institutional systems is one of the major characteristics of all institutional approaches. In this sense, it means that the system's performance and its capacity to innovate are supposed to depend as much on the system itself as on the characteristics of the different sub-systems. This will concern the forms of organization of industrial R&D and the characteristics of the public search and training system, but also, the structure of the whole economic system. The effectiveness of some institutional or organizational features cannot be assessed without taking into account the whole institutional structure. This implies in particular, the ideas of a required coherence between the society's institutional structure and firm's characteristics and organizational patterns, between institutional traits on the one hand and firms' patterns of behavior on the other.

The idea of a hierarchy between institutions also plays a key role in most of the institutional approaches. Edquist and Johnson (1997) make a clear distinction between two levels of institutions:

> Basic institutions are like constitutional rules or ground rules. They define basic rules in economic processes, for instance property rights and rules for cooperation and conflict solving in the labor market and in firms. Supporting rules define and specify certain aspects of the basic rules, for

example, restrictions on the use of the private property in specific situations and rules for regulating overtime work in specific industries.

This way of operating and evolving is the key for the understanding of the dynamics of the system and the individual firms according to the degree of autonomy opened to their initiatives by the characteristics of the institutional setting.

3.5.1.3. Building A Learning Organization

There is a strong synergy between the introduction of new forms of organization and the performance and innovative capacity of the firm (Lundvall and Nielsen, 1999). Establishing the firm as a learning organization characterized by decentralized responsibility, teamwork, circulation of employees between departments and investment in training has a positive impact on a series of performance variables. Flexible firms are characterized by higher productivity, by higher rates of growth and stability in terms of employment and they are more innovative in terms of new products. According to Johnson and Lundvall (2000), success in terms of innovation is even greater when such a strategy is combined with active networking in relation to customers, suppliers and knowledge institutions.

3.6. New Ways of Organizing the Firm

3.6.1. Reasons for Organizational Change

Intensified competition forces firms to find new ways of organizing the firm. Firstly, the need for efficient modes of organization promoting flexibility and innovation specializing in products with a limited growth potential in world markets, secondly, weak performance especially in information technology products, may reflect weakness in the organizational set-up.

3.6.2. Where Do the New Organizational Principles Come From?

The first approach on the new organizational principles was regarding the organization of the production and labor process (Piore and Sabel, 1984; Boyer, 1991 cited in Lundvall and Borrás). New flexible production system were defined as that the emphasis was on the ability to respond to new market signals and exploit the flexibility offered by IT-based production system (Lundvall and Borrás, 1997). Another approach refers to the formation of a new techno-economic paradigm rooted in information technology. According to Freeman and Perez (1988), it has been shown that there is a tendency to establish horizontal communication and functional flexibility within firms relating successful production and use of information technology. A third approach concerns with the formal and informal participation of workers in decision-making and on the delegation of responsibility to individuals or group of workers.

There is also ongoing debate on Japanese versus US principles of organization: The theoretical debate and management literature on the new forms of organization has given the Japanese firm as a model. The combination of life-time employment, job rotation, interdepartmental task forces and horizontal communication practiced in the big internationally oriented Japanese firms has been used as a prototype for the learning organization in the new techno-economic paradigm (Freeman, 1987).

Recent analytical contributions give a new picture of the Japanese firm as a model. The contributions by Nonaka (1991) and Nonaka and Takeuchi (1995) look behind the specific organizational forms and identify even more fundamental differences between the approach to organizational learning in Japanese and Anglo-Saxon tradition. According to Nonaka (1991), the most fundamental difference is that the Anglo-Saxon model puts a much stronger emphasis on the codified knowledge and the codification has become a goal in itself in the Western tradition. On the other hand, Japanese firms, tend to give the formation and use of tacit knowledge much more emphasis in the learning process, described as an upward spiral that moves between and combines tacit and codified knowledge. While analysis of the use of tacit knowledge gives better understanding, the weakness of the Western model for the production innovation, inter-firm cooperation and the mobility of expertise between firms have become more important because of the growing complexity of the knowledge base and the acceleration of innovation. Intra-firm cross-functional teams have to be over-layered by “integration teams”, including experts from universities and from other firms (Iansiti and West, 1997).

The dimension of worker participation is important in relation to the learning economy since learning organizations have to build on delegation of responsibility to individual workers or to teams of workers. It is difficult to implement organizational change without a minimum support from employees. The traditional forms of formal representation will necessarily gain or lose in terms of power. It indicates that changes will take place and that these institutions need to adapt themselves to the new context.(Lundvall and Borrás, 1997)

3.7. Networks

According to recent interpretations of innovation networks, firms and other economic actors in “learning organization” must have a high interest in entering network relations. This is especially the case when a high degree of specialization forces firms to complement their own competencies with external specialist knowledge. Networks bring together independent organizations in long-term relationships having information exchange, interactive learning and direct-co-operation. Thus, their “structure” is heterarchical rather than hierarchical, involving economic as well as social relationships. Network forms of governance give more flexibility, more stability, and efficient base for coordination and interactive learning (Lundvall and Borrás, 1997).

The importance of horizontal inter-firm cooperation in promoting innovations highlights the qualitative aspects of networking. Another point is that the network perspective helps illuminate the historically evolved relationships between the internal organization of firms and their connections to one another and to the social structures and institutions of their particular localities (Powell, 1990).

In innovative networks, especially the nature and range of interaction among firms and organizations engaged in innovation is crucial. Interaction in terms of knowledge sharing or innovation efforts occurs at the firm level between management and workforce, between firms in respect of pre-competitive collaboration, between firms and research institutes, between buyers and suppliers, and between firms and their governance systems. All these kinds of interactions, especially the share of tacit knowledge within organizations and between organizations depends to a large degree on trust and reciprocity forming the basis for collective and cooperative relationships among economic actors (Asheim and Cooke, 1999).

3.8. Knowledge-Intensive Services

Services are a heterogeneous set of activities that some services are small, labor-intensive using only primitive technologies while others are capital-intensive and major users of information and communication technologies. The services sector plays an important role in the innovation process that they influence and are significant catalysts for wider organizational and technological change affecting the learning capacity of the system. Lundvall and Borrás (1997) defined the sources of the internal innovativeness of knowledge-intensive services including the following dimensions:

Personnel and Human Resources Management: Their ability to recruit an ICT specialist, sector-specific and management personnel and employ them across a range of client applications. Their adaptive learning processes are augmented by a variety of project experience.

Proficiency in IT (Information Technology) Systems: Global knowledge-intensive services are developing advanced IT systems to support their own activities. They also play a significant role in adapting computer-based management systems for individual client circumstances.

Flexible, Decentralized Organization: The knowledge-intensive service firms are organized in innovative, flexible ways, cutting across the rigidities of formal organizations, employing project-based teams, and incorporating close working links with clients.

International and Cross-Sectorial Expertise Building: One of the main innovative features of modern knowledge-intensive services is the increasingly international scale of their experience and intelligence gathering. They are becoming a distinctive source of new ideas and expertise for many clients.

According to Strambach (1997), the role of knowledge-intensive services in the innovation process is tied to the 'products' these services supply to the market. Specialized expert knowledge, R&D ability and problem solving know-how are the real products. Another point is that the content of product gives indirect effect on innovation system by increasing the adaptability of knowledge-intensive services client firms. The interaction between supplier and customer is more intense where the transfer of knowledge and problem solving takes place as a process of mutual and cumulative learning (Strambach, 1997).

An important contribution of knowledge-intensive services to the learning is their role in the creation and distribution of both tacit and codified knowledge. The primary role of knowledge-intensive services firms' is to review the wide range of technical, managerial and marketing knowledge, through their own research and experience of collaborating with many clients, and to adapt and codify it for other clients. The profits of knowledge-intensive services depend on the active transmission of specialist knowledge and applications experience to client, and between sectors, regions and nations.

New and flexible institutions are needed to support learning processes in a globalized economy. Knowledge-intensive services provide a diversity of specialist expertise by a variety of means adapted to the needs of a wide range of private and public sector clients. The growth of knowledge-intensive services illustrates increased demand for new learning and change within firm and organizations as a way of enhancing the organizational and technological transformations of firms (Lundvall and Borrás, 1997).

3.9. Trust and Learning

Learning is a social process based on trust and social capital. Know-how grows in importance as information becomes more complex and abundant. What distinguishes the successful businessman from their more mediocre colleagues is know-how, or personal knowledge, for instance in the shape of experience based capabilities to interpret and give meaning to emerging complex patterns and to act purposefully on the basis of this insight. Know-how is typically learned at something similar to apprenticeship-relationships where the apprentice follows his master and relies upon him as his trustworthy authority (Polanyi, 1958; 1978). Know-who is learned in social practice and some of it is 'learned' in specialized education environments. Communities of engineers and experts are kept together by re-unions of alumnae and by professional societies giving access to know-trading with colleagues (Carter, 1989).

The learning economy needs a lot of trust in order to be successful. Kenneth Arrow has pointed out that 'trust cannot be bought: and if it could be bought it would have no value whatsoever' (Arrow, 1971).

3.10. Trust and Organizational Learning

Trust can be understood as a judgment under uncertainty formed over time on the basis of direct interaction among individuals. This view leads naturally to the idea that learning within or between organizations depends upon a certain degree of trust. Marengo (1996) made computational model of organizational learning. Although Marengo is largely concerned with the problem of establishing a common language within an organization in terms of condition/action rules leads naturally to an appreciation of the importance of trust (Lazaric and Lorenz, 1998).

The sharing of a common base of knowledge is a precondition for the members of an organization to communicate and to coordinate their actions effectively in an effort to solve the problems they confront. This problem can be modeled by treating each decision-maker as a set of condition-action rules which specify the execution of a certain action conditional upon the agent's perception of the present state of the world. A form of learning can then be analyzed by assuming that the rules that perform better gain in strength relative to others, by allowing for change through the recombination of the elements of existing rules to generate new ones. The dynamics of collective learning can be explored under varying assumptions about the importance of decision-makers attach to messages they receive from other organizational members situated at different levels of the organizational hierarchy. Organizational rules not only embodies knowledge about what actions should be taken in specified circumstances, but also constitutes political compromises which affect power relations and the distribution of organizational quasirents. Changes in the rule, the substance of organizational learning, become problematic because, given limited foresight and the possibility of opportunistic behavior, agents will be uncertain whether the proposed changes are designed to bring about mutual gain or to benefit others at one's expense. Mistrust of the intensions of others can lead organizational members to resist even relatively simple changes that promise mutual advantage. In this sense, some degree of trust is a precondition for organizational learning (Marengo, 1996)

According to Lazaric and Lorenz (1998), this rule-based framework can be adapted to the analysis of inter-firm learning. Both technological alliances and long-term partnerships between buyers and suppliers depend on the creation of a set of rules and procedures that allow firms to coordinate their decisions and to solve the technological and organizational problems they encounter. Elements of surprise and discovery will constitute critical conjunctures for technological partners because in such circumstances the incompleteness of the existing rules will call for the creation of new rules or the modification of existing ones in adapting them to new conditions. A certain degree of trust will be a necessary condition for individuals to risk such uncertain forms of cooperation. Given the bounds to human rationality, trust remains a tentative judgment, open to revision based on how one's partner adapts to contingencies, which offer the possibility of opportunistic behavior.

This suggests a conception of trust as a judgment, which comes about over time as part of virtuous circle of organizational learning, mutual gains, and revised judgments concerning trustworthiness. Within this conception, two sorts of obstacles to organizational learning merit attention. First, there is no guarantee that the trust, which favors organizational learning, will come about, since mistrust and failed learning may also prove mutually reinforcing. On theoretical grounds, there is little reason to preclude a vicious circle of mistrust and failed cooperation. The second obstacle to organizational learning derives from the fact that the build-up of trust requires an initial leap of faith, since; as argued above, the information about a potential partner which is publicly available inevitably leaves in place a degree of uncertainty (Lazaric and Lorenz, 1998).

In summary, a low-level of trust within an organization is an obstacle to learning, thus creating a self-sealing situation, because the existence of this lack of trust as an obstacle is not questionable. Making the lack of trust questionable requires a high level of trust, which of course presents a dilemma that a skilled interventionist can make the issue questionable, allowing this obstacle to implementing an organizational learning process to be surmounted. This solution to the problem of low trust raises a second-order trust problem (Lazaric and Lorenz, 1998).

3.11. Pressures on Firms to Make R&D

According to the OECD (1994) definition, "Research and Development in general is a creative work to increase knowledge of man, culture and society and use this to develop new applications”. Research is the search for a complete knowledge or understanding without specific application and induced research can be defined as the research to meet a corporate objective or strategy.

Research and development activities are seen as the determinants of the economic success and competitiveness of firms. There is also strong relationship between research and development activities and firm’s growth. Studies show that firms which are able to use research and development to differentiate their products and services from competitors are much more profitable than other firms. What underlines such contributions of research and development to the success of the firms is the direct relationship between R&D activities and the factors that are critical in determining firm success. These are the relationships between R&D activities and innovation, R&D productivity, and R&D and competitive advantage of the firm. (Griliches, 1995)

The R&D activities increase the probability of a firm to make product and process innovation. The evidence of the survey done by Griliches (1995) shows that there is a quite strong relationship between R&D and the number of patents. Since the firms get the patents for the innovations they make, the number of patents reflects the number of innovations; there is a positive correlation between R&D and innovation. Although R&D may not result in innovation in every circumstance, and innovations do not always have to come from R&D facilities, the two expressions are pronounced together most of the time owing to the high correlation between them.

Many studies show that Research and Development activities increase the productivity of the firms and there is a positive correlation between a firm’s R&D intensity and productivity. R&D results in induced improvements and extensions in technical and organizational know-how on economic magnitudes such as increase in productivity, turnover and profits (Cohen and Levin, 1989; Griliches 1995).

Functions of R&D can be classified in different ways. One of the possible classifications is according to the nature of the benefits R&D provides to the firm (Table 3.2). New opportunities can be developed by creating new products, processes and technology, by advancements in knowledge and understanding and by transmission of basic research to applications.

Table 3.2. Returns of R&D Process (Gellatly and Peters, 1999)

The Possible Returns of the R&D Process		
In terms of Customers	**In terms of the Company**	**In terms of R&D Itself**
-Meeting needs and expectations -Creating high value (lower total cost) -Increasing quality relative to competitors -Differentiating from other alternatives	-Accomplishing goals and strategies -Increasing sales and profits -Creating competitive advantage	-Increasing efficiency -Improving the learning process

Business strategies are responses to the competitive forces that shape the marketplace in which the firm operates. For example, in a price competitive marketplace, a firm's competitive position will depend largely on its ability to develop innovative production technologies that reduce unit costs. In this context, innovation will be geared towards realizing efficiency gains. In other settings, where a firm's competitive position depend more on its ability to bring new products to market, more resources may be directed into R&D in order to offer a differentiated product line to the consumer. Differences in the nature of competition engender differences in the type of innovation that is pursued.

The in-house research capacity of the firm is important for its absorptive capacity. Absorptive capacity is the extent to which firms can implement exogenously generated knowledge. Firms in innovative industries have to invest in complementary in-house research and development in order to understand and use the results of externally performed R&D and to obtain full access to the research findings of other firms and institutions (Mowery and Rosenberg, 1989). The innovative characteristics in the scope of a firm's goal to realize R&D studies are shown in Table 3.3.

Table 3.3. The Characteristics of Innovation Regarding a Firm's Goal in Making R&D (Gellatly and Peters, 1999)

Communications	**Financial Services**	**Technical Business Services**
-Improving product quality is a major objective of innovation -Improving product/service reliability is the dominant impact of innovation -Suppliers and technology acquisition are major sources for innovative ideas -Legislation is seen as an obstacle to innovation	-Reducing unit labor costs is a relatively more important object -Speed of delivery and adapting to customer requirements are dominant outcomes of innovation -Competitors are a primary source of ideas for innovation -Use of trademarks is extensive	-Customer diversification and production flexibility are more significant innovation objectives -Impacts of innovation are varied and intense: product reliability, adaptability, user friendliness, speed of delivery and accessibility -R&D is a major source of ideas for innovation -More diverse use of intellectual property instruments -Financing restrictions and labor shortages are key obstacles

At the micro level, technological innovation contributes to product effectiveness, commercial and financial success. Technological innovation is created by induced research. The induced research contributes to a firm's innovative capability, and increases the probability of the firm to innovate. Research and innovation enables the company to improve its products and processes or both. The competitive pressure of the rivals is one of the most important factors force companies to undertake induced research and innovate. Undertaking the research activities in-house is the best choice for most of the companies since it increases the effectiveness of the R&D activities.

3.12. Intellectual Property Rights

Intellectual property rights such as patents, is one way to limit the access of competitors to the core competences of the firm. They play different roles in different sectors but on average the move toward a 'learning economy' tends to make them less adequate. As the speed of change accelerates, it becomes more important for the firm to get access to new sources of knowledge (through recruitment, internal learning and networking) than to hinder to others to get access to its own competences (Johnson and Lundvall, 2000).

3.13. Concluding Remarks

It can be concluded that tacit knowledge and codified knowledge are the respectively, most important input and output of the learning process. Individual learning and organizational learning are central for the firm's knowledge base and innovative capabilities. Innovations can be regarded as 'learning results' leading to new knowledge. The concepts of innovation and learning will be examined under a case study of ASELSAN in Chapter 5.

CHAPTER 4

FIRM-LEVEL TECHNOLOGICAL CAPABILITIES

Up to now, it was argued that the role of tacit and codified knowledge in the economy deserves special attention as the basis for new transformations toward a learning economy.

In this chapter, firm-level technological capabilities are examined and defined, in order to establish an infrastructure for the case study of ASELSAN Electronic Industries Inc., which includes new product development and learning process model. The focus is on the dynamic capabilities of the firm, and the aim of this theoretical review is to develop an analytical understanding of a firm as a learning organization.

4.1. Elements of Technological Capabilities

Kim (1997) defines the term "technological capability" as the ability to make effective use of technological knowledge in efforts to assimilate, use, adapt, and change existing technologies and it helps to create new technologies and to develop new products and processes in response to changing economic environment.

Technological capability has three elements: *production*, *investment*, including duplication and expansion, and *innovation*. These elements of technological capability are outlined in Table 4.1.

Table 4.1. Elements of Technological Capabilities

Elements of Technological Capabilities
Production Capability -Production management to oversee operation of established facilities -Production engineering to provide information required to optimize operation of established facilities, including raw material control, production scheduling, quality control, troubleshooting, and adaptations of processes and products of changing circumstances -Repair and maintenance of physical capital according to regular schedule and as needed.
Investment Capability -Manpower training to impart skills and abilities of all kinds -Investment feasibility studies to identify possible projects and ascertain prospects for viability under alternative design concepts -Project execution to establish or expand facilities, including project management, project engineering (detailed studies, basic engineering, and detailed engineering) procurement, embodiment in physical capital, and start-up
Innovation Capability -Basic research to gain knowledge for its own sake -Applied research to obtain knowledge with specific commercial implications -Development to translate technical and scientific knowledge into concrete new products, processes, and services.

Source: Adapted from Wetstphal *et al.*, 1985 (pp. 167-221) cited in Kim (1997)

4.2. The Dynamics of Capabilities of Firms

According to Teece and Pisano (1994), the various dimensions of innovation strategy that is called the "dynamic capabilities" approach to corporate strategy underlines the importance of dynamic change and corporate learning:

"This source of competitive advantage dynamic capabilities emphasizes two aspects. First, it refers to the shifting character of the environment; second, it emphasizes the key role of strategic management in appropriately adapting. Integrating and re-configuring internal and external organizational skills, resources and functional competencies towards a changing environment." (Teece and Pisano, 1994, p. 537).

"To be strategic, a capability must be honed to a user need (so that there are customers), unique (so that the products/services can be priced without too much regard for the competition) and difficult to replicate (so that profits will not be competed away)." (Teece and Pisano, 1994, p.539).

"We advance the argument that the strategic dimensions of the firm are its managerial and organizational processes, its present position, and the paths available to it by managerial processes we refer to the way things are done in the firm, or what might be referred to as its 'routines', or patterns of current practice and learning. By position, we refer to its current endowment of technology and intellectual property, as well as its customer base and upstream relations with suppliers. By paths we refer to the strategic alternatives available to the firm, and the attractiveness of the opportunities, which lie ahead." (Teece and Pisano, 1994, pp. 537-541).

As discussed in the preceding chapters, information is central to the operation of firms and that it is a stimulus for knowledge, know-how, skills and expertise. Figure 4.1 helps to distinguish information from knowledge and know-how according to industrial context, which transforms knowledge into action, in the form of projects and activities. It is only when information is used by individuals or organizations that it becomes knowledge, tacit knowledge. The application of this knowledge then leads to actions and skills (projects, processes, products, etc.) (Trott, 1998).

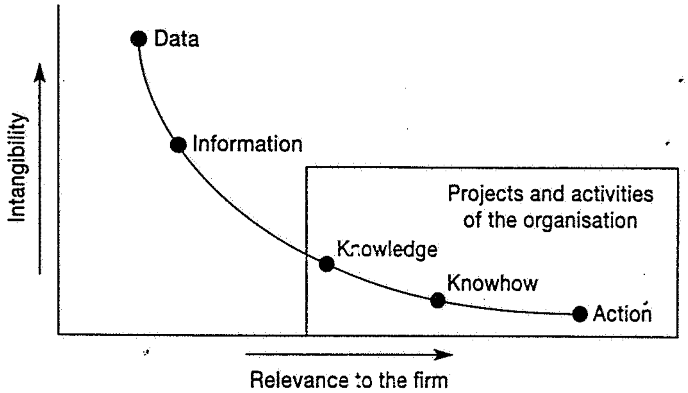

Figure 4.1. The Tangibility of Knowledge (Cooley, 1987 cited in Trott, 1998)

4.2.1. How A Firm Learns

Teece (2000) states that there are many dimensions of the business firm that must be understood to enhance distinctive competences/capabilities in business firms. Generally, how to minimize cost for a given output level comes to many more usual, but in developmental context, dynamic issues are more important (Teece, 2000).

'Dynamic issues' in developmental activity have three major dimensions:

(1) How to leverage existing assets into new and/or related business;

(2) How to learn;

(3) How to combine and recombine assets to establish new business and address new markets.

The challenge is to make sense of the rapidly changing context of global business and to find new ways of doing this. This typically involves new business models and transformational activity inside the firm as well as with customers, suppliers and competitors." (Teece, 2000, pp. 109-107).

Teece (2000) proposed that organizational processes have four roles: *coordination/integration* (a static concept); *routinization*; *learning* (a dynamic concept); and *reconfiguration* (a dynamic concept).

4.3. Firm-Level Innovation Models

Schumpeter (1939; 1942, cited in Trott, 1998) was the first economist to emphasize the importance of new products as stimuli to economic growth. He argued that the competition posed by new products was more important than marginal changes in the prices of existing products (Trott, 1998).

The Schumpeterian view sees firms as that the way a firm manages its resources over time and develops capabilities that influences its innovation performance. The varying emphasis placed by different disciplines on explaining how innovation occurs comes together in the framework is illustrated at Figure 4.2. This overview of the innovation process includes an economic perspective and organizational behavior which attempts to look at the internal activities. It also recognizes that firms form relationships with other firms and trade, compete, and co-operate with each other. It further recognizes that the activities of individuals within the firm also affect the process of innovation. Each firm's unique organizational architecture represents the way that it comprises its internal design, including its functions and the relationships it has built up with suppliers, competitors, customers etc. (Trott, 1998).

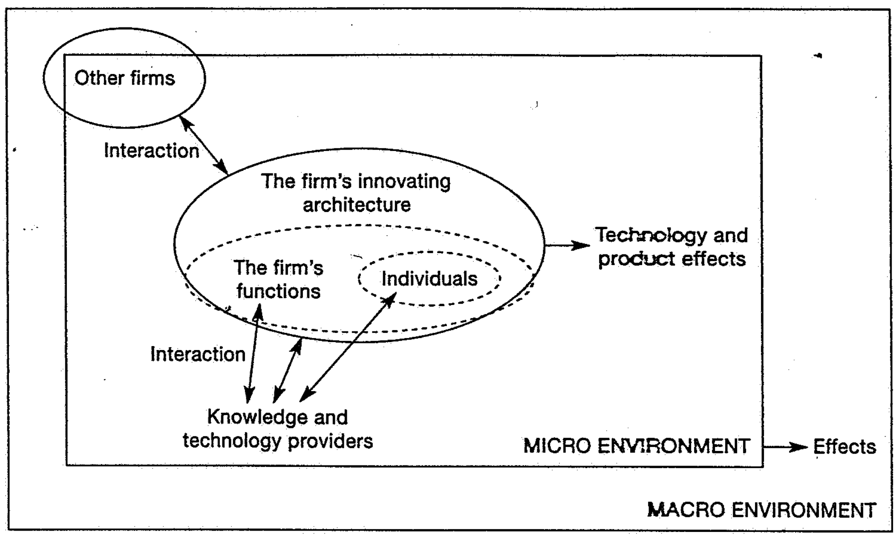

Figure 4.2. General Overview of The Innovation Process (Trott, 1998, p.8)

4.3.1 Five Generation Innovation Models

Figure 4.3 represents a generic process model of new product development in that it attempts to convey to the practitioner how the key activities are linked together to form a process.

Cooper (1983 cited in Trott, 1998) stated that the most comprehensive studies on new product success were undertakes. In this study, 12 activities were identified: (1) initial screening; (2) preliminary market assessment; (3) preliminary technical assessment; (4) detailed market study; (5) financial analysis; (6) product development; (7) product testing (in-house); (8) product testing (with customer); (9) test marketing; (10) trial production; (11) full-scale production, and (12) production launch.

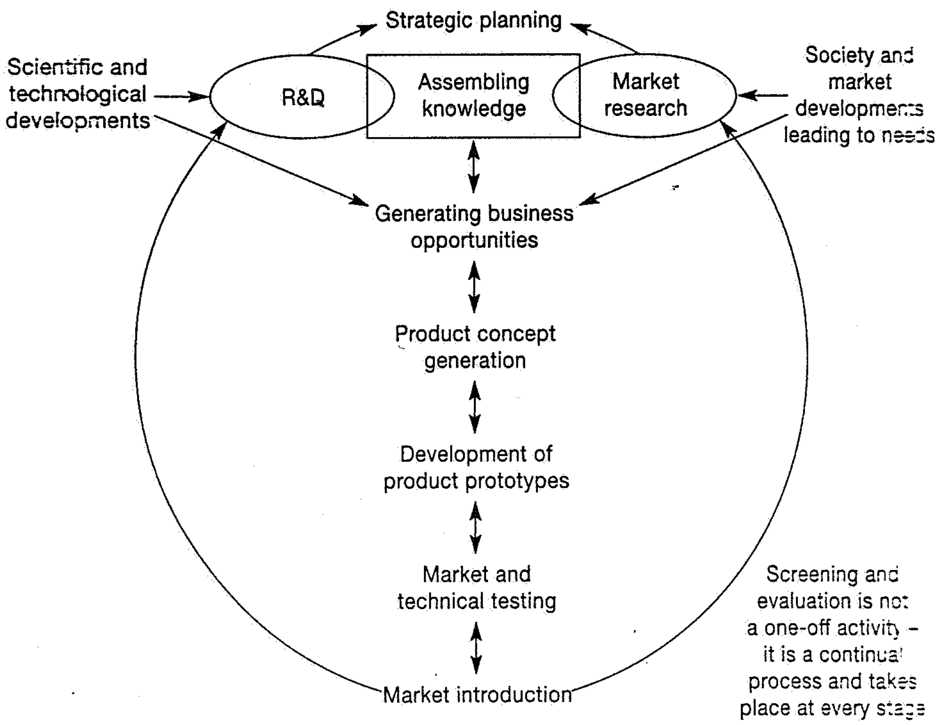

Figure 4.3. The New Product Development Process (NPD) as a Series of Linked Activities (Trott, 1998, p.141)

There has been a proliferation of innovation models purporting to explain or guide the process of innovation process within industrial firms since the 1950s. Dogson and Rothwell (1993) argued that the Post-War era was characterized by successive waves of technological innovation associated with a corresponding evolution in corporate strategy. Table 4.2 summarizes Rothwell's view of the evolution of innovation models from the 1950s to the 1990s in five successive generations.[6] Rothwell (1993, pp.1-2) emphasized that;

- The evolution from one generation to another does not imply any automatic substitution of one model for another; many models exist side-by-side and, in some cases, elements of one model are mixed with elements of another at any particular time;

- Each model is always a highly simplified representation of a complex process, which will rarely exist, in a pure form;

- Often progress from one generation to another reflects shifts in dominant perception of what constitutes best practice, rather than actual process;

- The most appropriate model will vary from sector to sector, and between different categories of innovation (e.g. radical or incremental);

- The process, which occurs within firms, is to an extent contingent on exogenous factors such as the pace of technological change[7].

[6] Most post-Rothwell models fall into the category of fourth or fifth generation.

[7] The importance of contingency was emphasized later by Drejer (1996) in his review of technology management approaches.

Table 4.2. Five-Generation Innovation Models

1st Generation Technology Push: 1950s to Mid-60s	Simple linear sequential process. Emphasis on R&D push. The market 'receives' the result of the R&D.
2nd Generation Market Pull: Mid-1960s to 1970s	Market (or need) pull; again a simple, linear sequential process Emphasis on marketing. The market is the source of ideas and provides direction to R&D.R&D has a reactive role.
3rd Generation Coupling Models: Mid 1970s to 1980s	Sequential model, but with feedback loops from later to earlier stages. Involves push or pull-push combinations. R&D and marketing more in balance. Emphasis on integration at the R&D marketing interface.
4th Generation Integrated Model: Early 1980s to 1990	Parallel development with integrated development teams. Strong upstream supplier linkages and partnerships. Close coupling with leading edge customers. Emphasis on integration between R&D and manufacturing (e.g. design for manufacturability). Horizontal collaboration including joint ventures and strategic partnerships
5th Generation System Integration and Networking Model: Post-1990	Fully integrated parallel development supported by advanced information technology. Use of expert systems and simulation modeling in R&D strong linkages with leading edge customers (customer focus at the forefront of strategy). Strategic integration with primary suppliers including –development of new products and linked CAD systems. Horizontal linkages including: joint ventures, collaborative research grouping, collaborative marketing arrangements etc. Emphasis on corporate flexibility and speed of development (time-based strategy). Increased focus on quality and other non-price factors.

Source: Compiled from Rothwell (1991 and 1993)

1) First Generation Models: Technology Push (1950s to Mid-1960s):

The first generation models of innovation can be explained as technology push models, which were simple linear models developed in the 1950s, as seen in Fig.4.4. As Rothwell (1991 cited in Dogson and Rothwell, 1993) argues, the model was then used to justify additional R&D spending by firms and governments and that this would lead to greater innovation, in turn, faster economic growth. Public policies towards innovation stressed supply side interventions (e.g. R&D subsidies and credits) in support of innovation.

Basic Science → Engineering → Manufacturing → Marketing/Sales

Source: Rothwell (1991, cited in Dogson and Rothwell, 1993)

Figure 4.4. First Generation Technology Push Models (1950s to Mid-1960s).

2) Second Generation: Demand Pull Models (Mid 1960s):

Figure 4.5 represents the second-generation model in which the marketplace was the chief source of ideas for R&D and the role of R&D was to meet market needs. These models were linear in nature, stressing the role of the marketplace (Rothwell, 1991 cited in Dogson and Rothwell, 1993).

Market Need →Development→Manufacturing→Sales

Source: Rothwell (1991, p.33)

Figure 4.5. Second Generation Demand Pull Models

3) Third Generation: Coupling Models (Mid 1970s to 1980s):

Third generation coupling models divide innovation into three spheres: exploration, innovation and diffusion. It is a practical business-oriented model with decision points and feedback loops, identifying key milestones in each phase as seen in Figure 4.6. The term (e.g. research, technical evaluation, engineering development, market research, sales and distribution) accompanies and interacts with each other during the innovation process. The main criticism of this model is that it does not sufficiently deal with the environmental factors (Dogson and Rothwell, 1993).

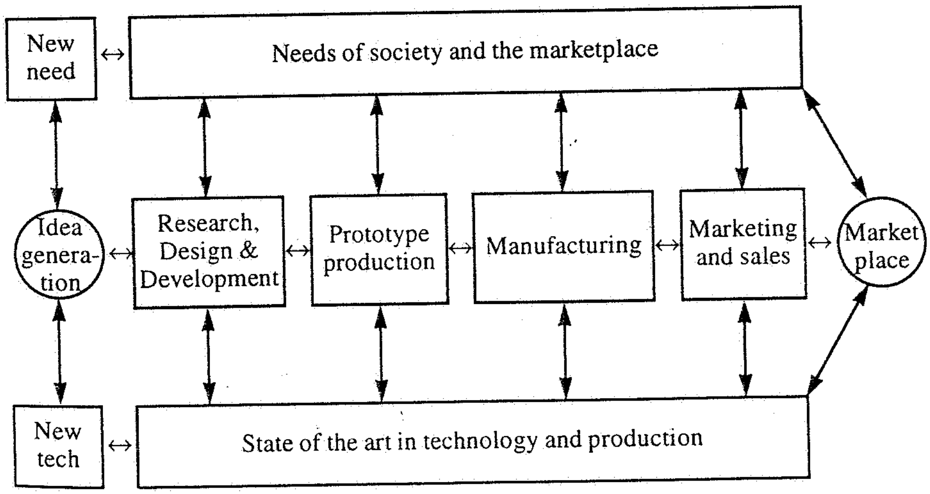

Figure 4.6. Third Generation Coupling Model (Rothwell, 1993 cited in Dogson and Rothwell, 1993)

4) Fourth Generation: Integrated Models (1980s):

During the 1980s, as seen in Figure 4.7, following observations of innovation in Japanese automobile companies, integrated or parallel models began to be developed which involved significant functional overlap between departments and activities. These models attempted to capture the high degree of cross-functional integration with activities in other companies including suppliers, customers and, in some cases, universities and government agencies (Rothwell, 1993 cited in Dogson and Rothwell, 1993).

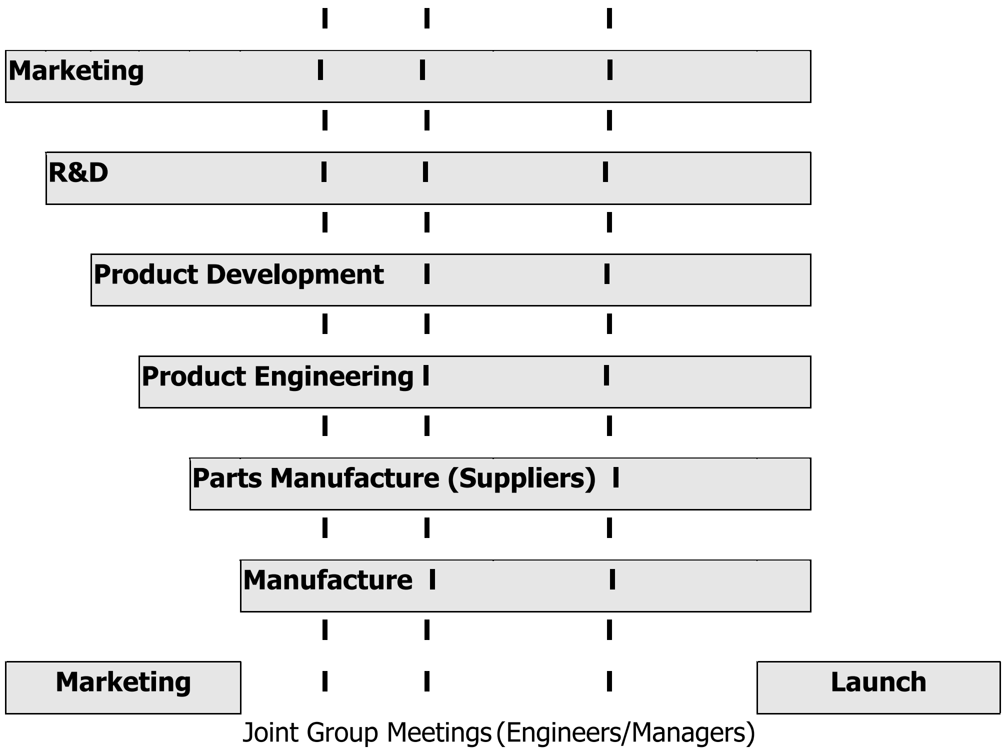

Figure 4.7. An Integrated Fourth Generation Innovation Model (Rothwell, 1993, p.22)

5) Fifth Generation: System Integration and Networking Models (Post 1990): Fifth generation systems integration and networking models emphasized the learning, which goes on within and between firms, suggesting that innovation as generally and fundamentally a distributed networking process. The models were based on observations during the 1980s and 1990s of an increase in corporate alliances, partnerships, R&D consortia and joint ventures of various kinds. These interpretations were extensions of fourth generation-integrated models, further emphasizing vertical relationship (e.g. strategic alliances with suppliers and customers) and with collaborating competitors. Rothwell's fifth generation process also relied on the sophisticated electronic tools in order to increase the speed and efficiency of new product development across the network of innovation, including in-house functions, suppliers, customers and external collaborators.

Rothwell (1993) argued that 5G (5th Generation) was driven by a range of interrelated factors including:

- Adoption of time- based strategies,
- Top management commitment and support,
- Horizontal management styles,
- Empowered product champions,
- High quality initial product specifications,
- The use of cross functional teams in development and prototyping,
- Designed in flexibility,
- The engagement of leading edge users in the innovation process.

Figure 4.8 presents a recent version of a fifth generation model.

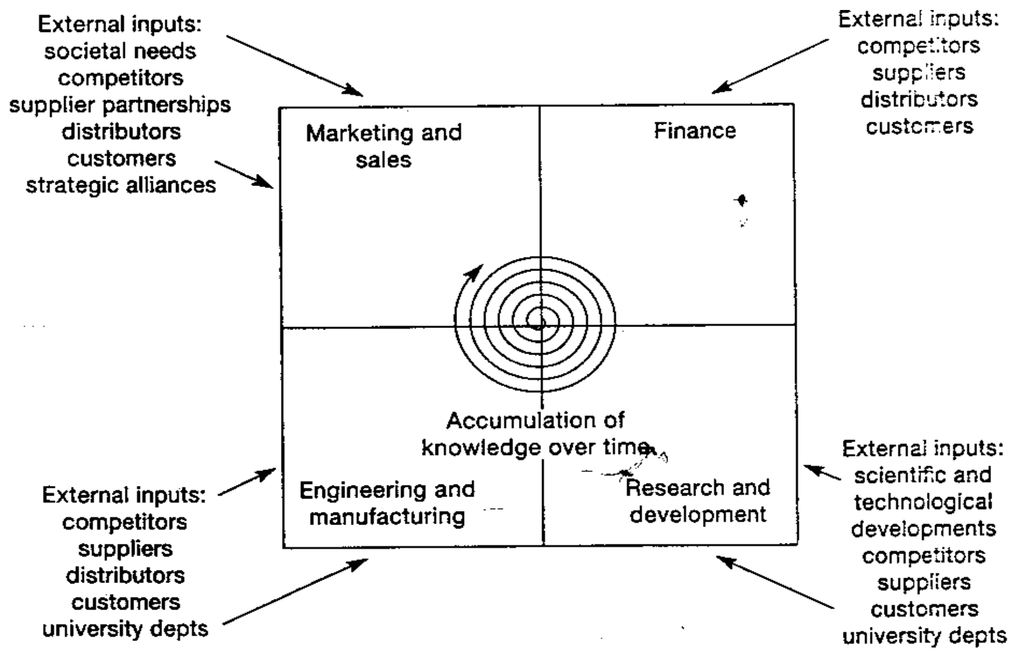

Figure 4.8. A Network-Based New Product Development (Trott, 1998, p.130)

With respect to fourth and fifth generation models, there is little evidence to demonstrate that firms have adopted these models of innovation or that, in case of fifth generation models, that is the adoption of information technology (IT) leads to the benefits proposed. The implementation of sophisticated IT systems can be costly and inefficient exercise, which can lead to worsening rather than improving performance. The ability of IT improve innovation efficiency probably depends on the nature of the product and technology in question and the depth of IT knowledge within the firm. While it may well be able to support 'lower level' routine tasks it is unlikely to be a substitute for essential human interactions, team building, group work and the leadership required in successful product and process innovation (Hobday, 2002).

Figure 4.9 presents product development times and cost relationships for the third and fourth and fifth generation models. The US was characterized as being mainly third generation. Japanese firms were praised for moving quickly towards 4th and 5th generation models, gaining from cross-functional developments and more effective overall integration, leading to high information processing capacity and more efficient new product development (Rothwell, 1993).

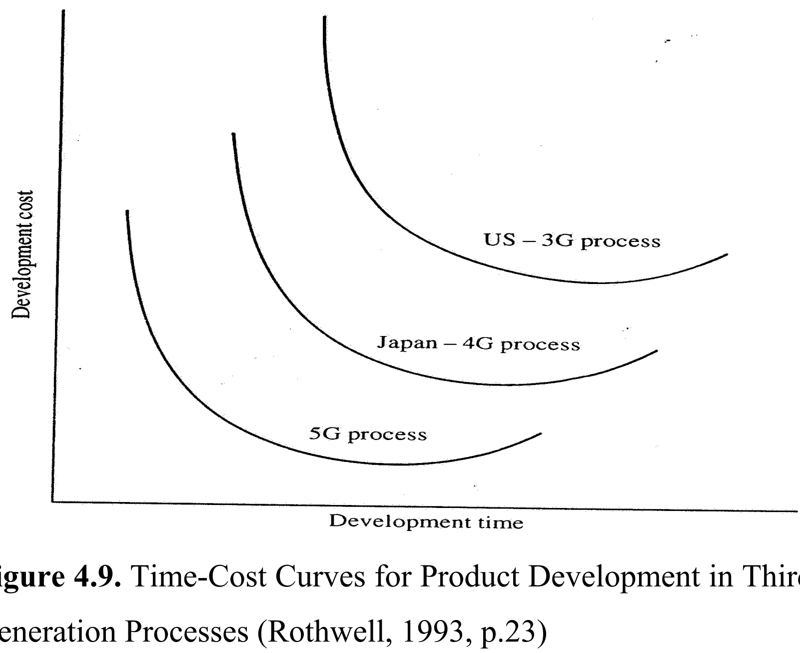

Figure 4.9. Time-Cost Curves for Product Development in Third, Fourth and Fifth Generation Processes (Rothwell, 1993, p.23)

4.3.2. The Catch-Up Dimension

Innovation models implicitly assume firms with leadership status and most are oriented towards large firms (e.g. with R&D departments and elaborate organizational divisions of labor), rather than medium or small firms, or small firms which might operate with more informal processes. Hobday (2002) states that most of the models deal with R&D centered activities, where innovation is defined in the strict sense as a product or process new to the world or marketplace. It is clear that the building of firm level innovation model understanding how catch innovation occurs and how it can be improved, is important for Korea and other developing countries for understanding past patterns of innovation models and guiding and improving current and future processes of innovation as latecomer firms increasingly reach the frontier, perform R&D and compete as leader.

4.3.3. Technology Transfer and Organizational Learning

Information is central to the operation of firms that it is stimulus for knowledge, know-how, skills and expertise is one of the key drivers of the innovation drivers. A conceptual framework of technology transfer should include;

- *Awareness*: Describes the processes by which an organization scans for and discovers what information on technology is available;
- *Association*: Describes the processes by which organization recognizes the value of this technology (ideas) for the organization;
- *Assimilation*: Describes the processes by which the organization communicates these ideas within the organization and creates genuine business opportunities; and
- *Application*: Describes the processes by which the organization applies this technology for competitive advantage (Trott, 1998);

Figure 4.10 illustrates how internal processes affect an organization's ability to engage in inward technology transfer and to contribute to the development of a receptive environment.

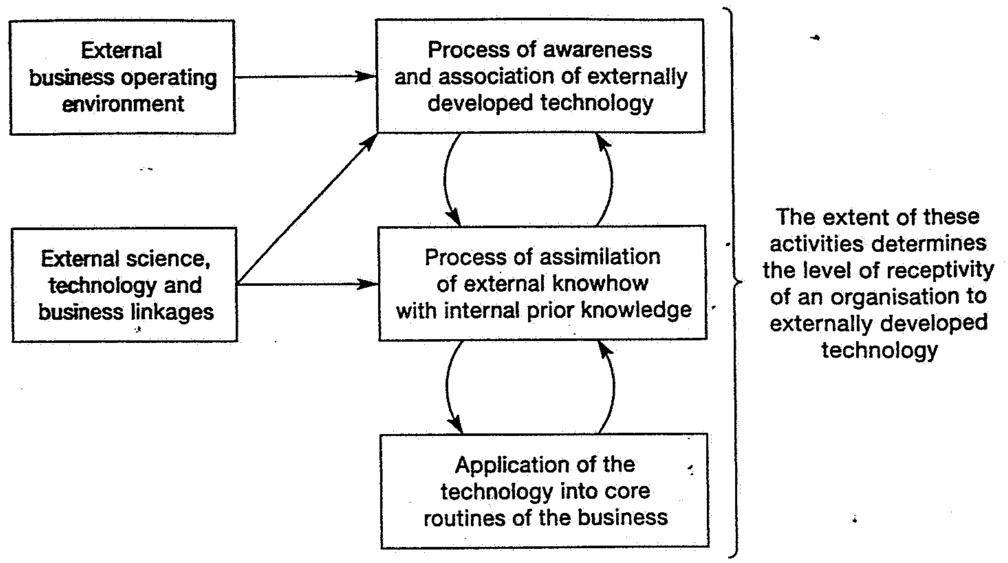

Figure 4.10. The Inward Technology Transfer Process (Trott, 1998, p.243)

In order for inward technology transfer to take place, members of organization must show an awareness of and receptivity towards knowledge acquisition. Individual learning involves the continual search for new information of potential benefit to the organization. In order for the organization to learn, the knowledge must be assimilated into the core routines of the organization, i.e., the knowledge becomes embedded in skills and know-how (Trott, 1998).

4.3.4. Linking IAC Models to Developing Countries

After Utterback and Abernathy (1975) proposed Industrially Advanced Countries (IAC) innovation models with innovation links, Kim (1997), connected to the model with innovation process in developing economies.

Kim (1980) proposed a three-stage model, with developing countries moving from acquisition of foreign technology, to assimilation and eventually to improvement. Initially firms acquire mature, foreign technologies from IACs, including packaged assembly processes, which only require some limited local production engineering. In the second phase, process development and product design technologies are acquired. In the third phase R&D is applied to produce new product lines and the sequence of IAC innovation events is 'reversed' with developing countries moving from mature to early stages of the innovation process. Hobday (2002) analyzed the study where Lee *et. al.* (1988) linked the reversed sequence with Utterback and Abernathy (1975) building on Kim's (1980) model. In the first phase, the "Utterback and Abernathy Model" is presented in which the rate of innovation is high in the early fluid stage while the rate of process innovation is low. In the transition stage, a dominant design is selected buyers in the market place and supplier begins to fix on a specific process technology. In the third phase, competition is largely based incremental process improvements as product design matures (Figure 4.11) [8] (Hobday, 2002, p.31).

Kim and Lee (1987) and Kim (1997) proposed that specific patterns of catching-up are contingent on the mature of the production technology that continuous process technologies are usually least differentiated in terms of product but the most capital and process intensive and the primary emphasis on production process capability and acquiring the detailed proprietary know-how embodied in foreign production process.

Hobday (2002) underpinned that these studies provide a useful and creative approach to understanding catch up innovation in the developing countries and can

[8] In this version of the catch-up model (Lee *et. al.,* 1988) developing countries catch-up not only mature technologies but also during the transition and fluid stages while progressing in their capabilities. Later, Lee and Lim (2001) extended this model by postulating the possibility of 'stage skipping' opportunities that at the advanced stage, firms in developing countries (e.g. Korea and Taiwan) are increasingly able to challenge leading firms in the advanced countries (Hobday, 2002, p.31).

provide the basis for further detailed research on firm level innovation management.[9]

Further analysis would also be useful for incorporating fourth and fifth generation model insights into the catch-up process (e.g. the role of networking and information technology) and future work could be useful guide firms in their innovation management strategies and for enabling government policy maker to differentiate policies to the capabilities of firms (Hobday, 2002).

4.3.5. A Resource-Based Theory of Innovation

Innovation is a dynamic process, embedded in within the firm and modern resource-based theories of the firm is the a good place for starting point to develop a realistic model of innovation model to provide frameworks for analyzing internal competence and strategic variety.

Resource-based theories of the firm assume that companies have access to specific internal resources and competencies, which interact with the environment in which they complete. In the original resource-based approach, authors such as Teece and Pisano (1994) have proposed a dynamic-capability view of the firm.[10]

In this theory, positions referring to the actual market relations and resources of a firm at any point in time, is dividing resources into two main categories: technological and complementary, showing how the positions of a firm is shaped by its historical internal learning process, corporate history, key strategic decisions and past market successes and failures (i.e. paths). Paths refer to the past and future possible business directions of the firm including actual patterns of technological innovation, organizational learning, product market achievements

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[9] They show that contingency factors such as the nature of product technology, the impact of government policy and the importance of the socio-economic environment are central to innovation (Kim, 1997).

[10] Teece and Pisano (1994)'s studies about the formulation of 'positions, paths, and processes of individual firms draw on dynamic models of innovation (Utterback and Abernathy, 1975).

and financial investments. Processes occur within and across the various functions of the firm (e.g. marketing, production, finance, engineering, R&D and personnel) and occur both formally and informally, shaping the efficiency and effectiveness of a firm (Teece and Pisano, 1994).

4.3.6. Methodology Used in Korean Firms

According to a case study on technological innovation of Korean Firms (Hobday, 2002), empirical research might be able to show how firms arrive at their particular innovation process or model showing what a resource-based model ‘looks like’ in practice. Evidence that gathered on contrasting types of innovation models helps to understand the key factors which determine the evolution of innovation process, including variables such as management strategy, technology/product, sector requirements, leadership and so on. A jigsaw puzzle model used in Korean firms in given in Appendix B.

4.4. Learning Process Models

Learning is central to knowledge-based development that innovation capabilities of firm and social capabilities adapt to change and get improved through learning. According to Gu (2000), there are three distinctive paths or models of industrial latecomer learning:

a) Individual firm-based latecomer learning, with Korean firms as prototype;
b) Network-based latecomer learning, with Taiwanese firms as prototype; and
c) ‘Re-combination’ latecomer learning which takes place during profound transition in economic regimes, with Chinese firms as prototype.

Gu (2000) proposes that latecomer firms in developing countries are inexperienced or novice learners. They are an inexperienced group of firms in generating new products, new process and in creating new markets to capitalize on their product and process innovation. Making innovation is the quality of experienced firms typically grown in the advanced market economies. The success of the catching-up process of a developing economy depends on how the firms learn to become experienced innovators. But firms are dynamic human organizations. Some firms are entering and arising, some declining or extinguishing. The notion of latecomer firms is, aggregate through, real, measuring the level of productivity or the unit value added competitive exports could capture it (Gu, 2000).

Firm's learning links to the context of its institutional structure. The profiles of national innovation system in which firms constitute an important part, and the trajectories of technological and institutional development are country-specific that each individual economy develops unique institutional structure. Analyzing institutional structure, the concentration degree of firms is taken in a certain sector as a reference point. In a large firm's dominant structure, learning takes place within the territory of individual firms, whereas in a small firms dominant structure, analyzing learning process needs to embrace interactions between firms (Gu, 2000).

A firm's intangible assets are the firm's knowledge basis such that only tangible assets of firm are counted. They can be classified into three categories:

1) The general understanding of scientific and technological knowledge, which is largely embodied in the firm's members, acquired from their training in the formal educational system of the society.
2) Firm-specific knowledge including technical and organizational knowledge;
3) The products and services the firm provides at the marketplace as the outcome from firm specific learning (Gu, 2000).

4.4.1. Learning Model 1 : Individual Firm-Based Latecomer Learning

According to Gu (2000), this type of learning process highlights the dynamic of cyclic upgrading in technological capability acquisition of individual firm-based learning. The mechanisms of the learning are learning input, learning process, learning output and organization and management of firm.

The theory of life cycle of technology (Abernathy and Utterback, 1978) is widely cited in explaining evolutionary dynamics of technological innovation. The theory contends that the rate of innovation for both products and processes follows a general pattern unfolding over time. The horizon of lifetime of technology is divided into three phases that sees a great deal of experimentation in product design and operational functions of technology competitors. A transitional phase follows in which the rate of major product innovation slows down and the rate of major process innovation speeds up. A dominant design appears in the middle of the phase and product variation gives the way to standard design. The third phase is called 'specific phase' in which product and process innovation takes small incremental steps focused on cost, volume and capacity, to substantiate returns of technology.

<u>Learning Cycles at a Korean Firm:</u> The case of Hyundai (Kim, 1997, pp. 105-129) is represented as an individual firm-based latecomer learning. Reverse traveling along with the life cycles of technology is well agreed to be characteristic of catching-up process by Korean firms. Hyundai began with conventional model by means of car assembling. Cyclically reverse traveling the curve of technology life cycle from more codified to less codified technology is the characteristics of the learning. At Hyundai, there are four learning cycles:

- 1968-1972: assembling,
- 1973-1977: imitating,
- 1976- 1986: advanced imitative design,
- 1984- 1990: brand design

<u>Learning Mechanisms:</u> In this part, the reasons for that Korean firms claim up the ladder to master increasingly sophisticated innovation capability is explained in the following learning mechanism items:

1) Learning Input: Well-educated engineers and managers though initially inexperienced, were the internal principal players of learning and the input of high-level human capital has been very intensive. In the early stages, Hyundai engineers were sent to work at Ford to obtain and bring back assembling experience. Later on, the focus on learning had turned on to design. Hyundai relied on unusually high human capital input including several leading experts who received Ph.D. degree and had worked in the world's leading companies. Cultivated learning ability of engineers gained from advanced specific and engineering education served them to the capability to absorb knowledge from external sources. They afterwards formed the core of the task force for the development of firm-specific knowledge. R&D came in Hyundai in the second cycle and began with intensive testing, a key component of reverse engineering.

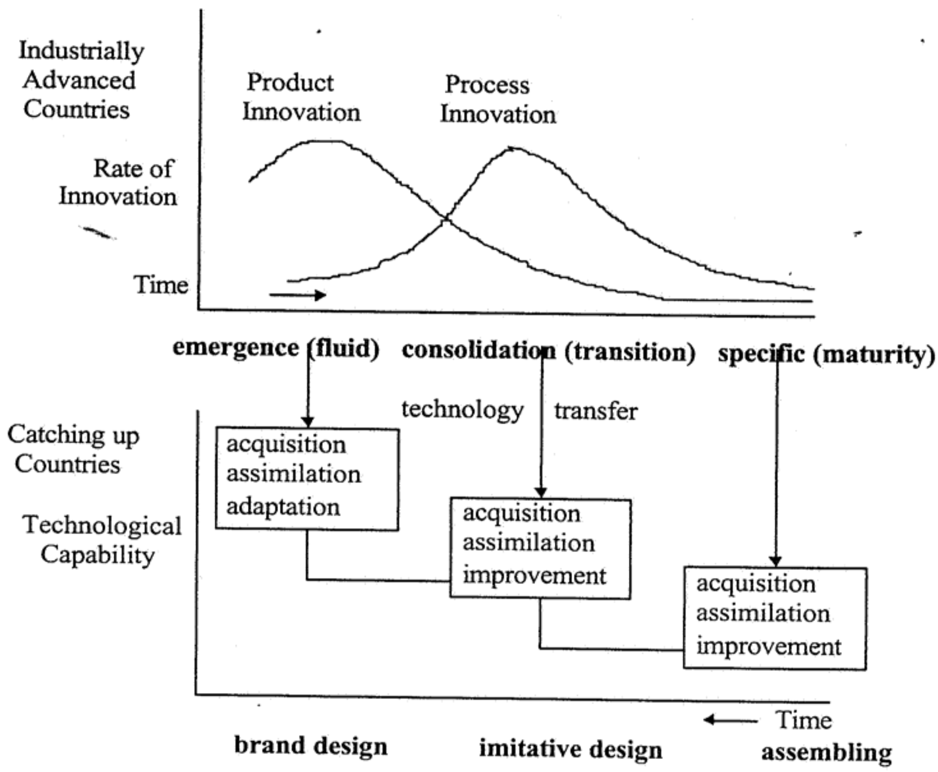


Figure 4.11. Capability Upgrading Through Enhanced Learning (Kim, 1997)

2) Learning Process: Learning at a firm involves collective action. To transform an inexperienced firm as to become capable of innovation and knowledge creation, setting-up ever-higher goals in terms of capability acquisition is a necessary condition leading to organizational learning to the creation and deepening of firm-specific knowledge.

3) Outputs of Learning: Output of learning is knowledge that has specifically resulted from absorption, practice and adaptation of externally sourced knowledge. The cyclic and up-moving sequence of learning paved the way in which basis of a firm gets accumulated in selective direction with particular strength and weakness. A firm's specific knowledge is systems-design and production.

4) Organization and Management of Firm: Unique features in organization and management are thinner layers of hierarchical structure. Pervasive employment of the task team is the other property in a latecomer firm's management. These organizational and managerial means offers a flexibility to mobilize limited resources for targeted entry into higher levels of capability as well as new fields of business, and associated capability upgrading.

A review of Hyundai history shows that the inducement by a developmentalist government had been crucial and financial policy instruments had long been taken to give incentives to firm's purchasing of foreign technology and in-house R&D (Gu, 2000).

4.4.2. Learning Model 2 : Network-Based Latecomer Learning

The cyclic and up-moving learning process based on individual firms has been well known with the writings by Kim (1997) and Hobday (1995). Increasing sophistication and complexity has driven technologies' 'unit' structure, seen in continuous manufacturing (for oil refinery, petrochemicals, steel and semantics (Rosenberg and Nelson, 1994), and modular structure seen in discrete manufacturing sectors such as machinery and electronics that focus on discrete technology [11]. To analyze latecomer's learning in network structure, Taiwan offers a good example.

Structure of Firms in Taiwan: Firms are operating in network and the distinction between vertical integration and network structure is relative. The life cycle theory is blind to the development of this model the reason for that for complex technology systems like machinery and ICT, the mature phase is extended and diversified. To analyze latecomer's learning in network structure, Taiwan is a good example. The ICT industry is a newly emerged industry, originated in the United States and other advanced economies that in the ICT area where the pace of change is rapid and applications are widely diverse.

Learning Input and Output, and the Role of Human Capital: Knowledge input on network structure in Taiwan has been intensive the output of learning was reflected in improvement in capability mastery in Taiwan. The mastery of innovative capability supported the move of export-oriented production from OEM (original equipment manufacturing) to ODM (own design manufacturing) to OBM (own brand manufacturing), as Hobday (1995) summarized. To be able to design for ODM and OBM implies that technologically the learner has managed 'know-how' about the technology, which often requires substantial scientific experimentation to de-codify and re-codify the knowledge involved.

[11] For trends in modular structure or subsystem structure, the experience of Silicon Valley provides a good illustration that centered in the approach of 'opening system architecture'. In the 1980s, Sun Microsystems opened its systems-architecture. Opening systems-architecture turned proprietary knowledge basis into shared knowledge infrastructure for a network community (Gu, 2000).

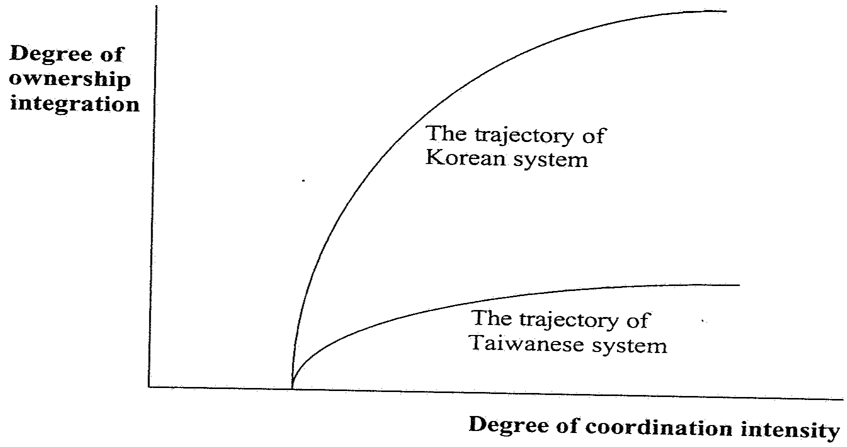


Figure 4.12. Trajectories of The Korean and Taiwanese Systems

4.4.3. Learning Model 3 : 'Recombination' Latecomer Learning in Economic Transition

'Combination', 'recombination' or 'technological fusion' are frequently used in the literature of technological innovation, meaning that technological innovation is often a process in which elements which have been generated and used elsewhere are combined in a particular new application (Kline and Rosenberg, 1986; Kodama, 1990). The term 'recombination' latecomer learning have large scale institutional restructuring and with systematic technological searching and learning to fill in missing dimension s of knowledge. Horizontal information flows took place among firms and between firms and R&D institutes propelling the trial error of the restructuring of micro-institutions. This model is based on the evidence in China.

A characteristic feature of dynamic learning system is expressed as technologic change which proceeds in some particular directions and not in others. It takes the path that is cumulative in which innovative capacity is built on and extends the knowledge and skills developed in the past.

The survival and re-consolidation of the industries was a result of intensive technological learning and institutional restructuring. Several processes were identified for re-combination latecomer learning observed in the 1980s and 1990s in China:

1. The withdrawal of direct government intervention and opening to international trade; macroeconomic environment thereby changed increasingly to rely on market mediation for resource allocation and information flows.
2. The direction of previously accumulated capabilities in production, design, R&D, and testing into novel and productive ways to meet challenges of market reform and trade liberalization.
3. Intensive learning made by many actors devoted especially to identifying and filling gaps in the inherited capabilities.
4. The intensive effort for institutional restructuring of many economic agents that supported development. The four parallel processes constituted the so-called 're-combination' latecomer learning typically observed in the 1980s-1990s China (Gu, 2000, p.18)[12].

In terms of direction and characteristics of technological development, two changes resulted from the learning; one is skills and competencies for firm and improved user-specific technology, second, applications of ICT became the focus of innovation effort.

4.5. Concluding Remarks

This chapter gives a foundation as by summarizing reviews on the important links between innovation and learning process within the firm, technological capabilities, new product development, technology transfer in order to prepare a basis for analyzing ASELSAN as a case study. In addition to serving as a foundation for understanding the whole picture, the various models that have been widely used by companies within "Industrially Advanced" countries to guide the innovation process have been explained in detail. Major consultancy firms

[12] The discussion of this model is based on the evidence in China resulting from a several years study by the author and collaborator (Gu, 1999; Gu and Steimueller, 1997).

frequently adopt one or other of these innovation models, and further develop them for guiding business wishing to improve their innovation process. Various kinds of spiral models are used within the field to provide guidance on how to manage the software process through life cycle.

Rothwell's (1993) idea of five generations enables us to chart the progress and sophistication of various models, the implicit assumptions adopted by innovation research. The five generations is a useful device to assess the way firms are approaching innovation and for suggesting possible improvement to innovation procedures.

This chapter brings us to the point of view that 'Individual firm-based latecomer learning model' can be an appropriate model that explains the ASELSAN's learning process due to the fact that ASELSAN started as an individual firm in the field of defense industry.

CHAPTER 5

AN EXAMPLE OF 'LEARNING PROCESS MODEL': ASELSAN

The basic aim of this case study is to explore the relationships between learning and innovations. However, this study also seeks to provide an account of learning process model. It is concerned to discover how organizational structure changes, how learning takes place and in which ways it influences the economic performance during the technological transformation.

As ASELSAN Electronic Industries Inc., being one of the most significant firms using and producing high technology in Turkey, has given priority, since its establishment, to well-educated human resources, R&D studies, and collaboration with university in order to produce high technology-based equipment and systems, it was chosen as the case study in this thesis.

This chapter includes the development of radio communication within the period 1980-2002 in order to represent the firm-level technological accumulation and transformation process. The central point of this case study is the learning process model of ASELSAN, which is explained with reference to the 'individual learning process model'[13], being one of the three latecomer learning process models (Gu, 2000). As discussed in Chapter 3, individual learning and organizational learning are viewed as the key "inputs" to the "learning process model" underpinning the crucial process of innovation. However, both are themselves to some extent dependent upon the level and the nature of the institutions (or form of social capital). Economic competitiveness (and the growth) is a key 'output' of the

[13] Other 'learning process' models are network-based model and 'recombination model' (see Chapter 4).

system. Equally, social inclusion is necessary as a further" output", if the system is to be sustained in the long term (Lundvall, 2001).

First of all, a general overview of the defense industry, and especially the defense industry of Turkey, is given to form a basis for the ASELSAN case study, then the overview and history of ASELSAN is presented.

5.1. The Defense Industry

The defense industry is a sector where the valid rules at the consumer sector can not be applied on an exactly similar basis due to its special conditions like, dependability on a single customer, the obligation to realize production special to this customer and based on limited requirements, security and privacy. Moreover, the defense industry is focused at the most advanced technological fields at all times, research, original technology and product development, in a continuous need of developing measures-antimeasures. With their suitable public supply approach, developed western States have well evaluated these features of this sector and they have successfully applied the defense industry to develop the scientific and technological infrastructure of their countries.

At the level of the main systems and technologies, the defense industry firms in these countries have become a major and effective force in the international market together with the conscious public supply policies applied in the framework of a contractor-subcontractor model based on an inter-firm task distribution and cooperation This model, which is technology-focused and has been determined parallel to the strategic science/technology policies of the country, is widely being utilized only at worldwide strategic sectors like defense, aeronautics/avionics and space industry. The developed countries which have long before adopted this practice, have enhanced and improved this model much more in the last few years and they are trying to develop their defense industries into a more yielding and powerful structure via inter-company alliances.

Similar approaches could not be applied in our country for a long time due to the fact that supply-procurement policies that will enable for the development and organization (at a specialty-base) of the national defense industry firms were not put into force.

In fact, the struggle to establish a modern and self-sufficient defense industry dates back to 1920s when the Turkish Republic was established. In this period, the studies regarding self-sufficiency were realized in the scope of the general industrialization activities and military factories were founded. However, starting from 1950s, together with NATO membership and the arming process being dependant upon foreign support, which had commenced with USA aid, a silent period had started. The second term in the defense industry investments of Turkey has started with the USA embargo arising after the 1974 Cyprus Maneuver. During this period, various foundations concerned with empowering the Armed Forces were established and investments were made at the electronics sector being deemed as one of the most critical sectors of the time. The 1980s have witnessed a third period for the defense industry that has started with one good and one bad news. The good new were at the country had decided to empower the defense industry in the scope of a new industrialization move. The bad new were the experimenting of the application of the liberalization policies, which had been successful at the civil sector, at the creation of the defense industry sector. This model, which had been practiced without giving due consideration to the characteristics of the defense industry, unfortunately could not give the expected results also with the insufficiency of the technology management policies. The Defense Industry Undersecretariat, which had been established in 1985 to support the development of the defense industry, gave support to the formation of "Joint Venture's, each formed of national and international partners, for each of the important defense supply programs and thereby, some production technologies were adopted on a project-base. However, as a natural outcome of the practical model, the sufficiency regarding original technology production and product development could not be attained in the short-run. The programs based on original technology were only realized by only the national companies.

“The Bases for the Turkish Defense Industry Policy and Strategy” which was issued on the date of 20th June 1998 as the 98/11173 no. Prime Ministry Decree has been a turning point regarding this subject. The decree brings about several important innovations both in terms of its policies and the models. In this period, starting with the issuance of this decree, if the body of laws are applied and institutionalized, as they should be, the country is to enter the greatest industrialization and technology development phase in its history. Since both this decree and the practice regulation issued by the National Defense Ministry, give due consideration to the characteristics of the defense industry and aim at the development of the national scientific and technologic infrastructure. This decree addresses the national firms for the technology and systems that should be embodied as original in the country, and it warranties the permanency of technology acquiring and original product development.

With this new model brought about by the above mentioned decree, it is aimed at acquiring the systems and technologies as **original**, which might be procured from the international sources but should be developed nationally due to the inconveniences in their utilization based on security reasons. While realizing all of these, it is aimed at developing a dynamic infrastructure for the defense industry, without alienating from the global advances and being open to the foreign sectors. However, the target of advancing our country from a position where our national firms are empowered and thereby given technological independency and forming a market, to a position where it is being cooperated in the international field has a priority in this process.

When technology is considered in the scope of the defense industry, the complete range of R&D, design and production that enables for the development of new version technologies and products should be comprehended. If the technology transfer that are realized via license acquisition do not provide for the production of new version technologies via assimilation by a strong R&D organization or new designs are not realized; then it is impossible for the purchased technology to be competitive or increase the military dissuasiveness.

The defense industry, being an industrial branch where factors like reliability, continuity, performance and cost-effectiveness take the lead, aim at the advanced technologies that are at the development stage. Therefore, the "transferability" of these technologies, which are strictly protected at the originated countries, although the cost may be paid, should be deemed in a realistic manner.

The fact that the products at the defense industry are being developed and produced/manufactured with very advanced technology and the fact that this technology should be continuously renewed, speed up the dissemination of modern technology utilization at the research, development and production infrastructure and attach due consideration to the work-labor training and education. Consequently, the struggles to establish a high-technology National Defense Industry infrastructure should not be only viewed as a tool for the procurement of modern defense systems, but also as a strategic target that is necessary for the continuance of the effectiveness in the science and technology field.

The main targets of the national defense industry are to minimize the foreign-dependability of Turkey in this field and to maximize the military dissuasiveness being one of the most important sanction powers at international affairs. The modern defense superiority and the military dissuasiveness are measured by the effectiveness of the possessed soldiers or the military systems, not by their numbers. Together with the advancing technology, the effectiveness criteria of the defense systems have also modified and new criteria such as reliability, preparedness and real-time operations have been added to classical criteria like caliber, range and action capability. These new criteria determine whether the current defense systems, which can be defined as high-tech hardware operating under the software-control, can or cannot be utilized at the correct time and location, in a fast, flexible and reliable manner.

To sum up, in order for the achievements of Turkish industrialization process and to increase the competitive ability in the international market(s); the national technological capabilities should be elevated and for this to happen, **first of all, the original technology production in Turkey should be supported by the government.** The **second way** to improve our national technological capabilities is **to transfer and assimilate the foreign technology by the national companies, before getting into cooperation with foreign firms.** Foreign partnership should be considered in cases where it is not so important to acquire the technology nationally and where national economic advantages could be gained with this manner. If advanced technology acquisition is aimed, foreign capital should be left out of consideration.

In the globalizing world, the countries will gain prominence/prestige and economic power in proportion to their technological capabilities. It is highly probable that Turkey, possessing a young population, is to be among the producers, not just a user, of at least some of the information systems. This can be realized if the government utilizes its policies aimed at correct utilization of this potential and does not consider foreign capital in the fields where high/advanced technology is inevitable.[14]

5.2. General Overview and History of ASELSAN

ASELSAN (Electronic Industries Inc.) was established by the Turkish Armed Forces Foundation at the end of 1975 to produce tactical military radios and defense electronic systems for the Turkish Army (these equipments were necessary in the Cyprus War). In the early 1979, following an investment and infrastructural establishment period, ASELSAN started its production at Macunköy-Ankara facilities. Since its foundation, ASELSAN has expanded its

[14]'Defense Indusry' part is summarized from Ziylan, A, 1999, 2000 and Zaim M. 1997, 2000.

product and customer spectrum, depending on qualified personnel, high technology, and knowledge.

ASELSAN has two facilities in Ankara: Macunköy Facility (Figure 5.1) and Akyurt Facilities (Figure 5.2). This thesis study was performed at the Macunköy facility.

Figure 5.1. The Macunköy Facility (Source: www.aselsan.com.tr, 2003)

Macunköy facilities are established on a total area of 153.000 m^2 with a covered area of 76.000 m^2 as shown in Figure 5.1; this is the place where The Communication and Microwave and System Technologies Divisions are located.

Figure 5.2. The Akyurt Facility (Source: www.aselsan.com.tr, 2003)

Akyurt facilities are established on a total area of 243.000 m^2 with a covered area of 36.000 m^2 as shown in Figure 5.2; this is the place where Microelectronic Guidance and Electro-Optic Division continues its activities.

The shareholders of ASELSAN are shown in Figure 5.3, where it can be seen that the Turkish Armed Forces Foundation holds the majority of the shares (approximately four-fold as compared to the other shareholders). The Total Capital of ASELSAN is calculated as 29.403 Trillion TL.

Figure 5.3. Shareholders of ASELSAN (Source: Annual Reports and Internal Data, 2003)

In the beginning, the foundation of ASELSAN was aimed to meet the Turkish Armed Forces communication system needs. 4600 Series Tactical Vehicular, Trunk, Man-Pack Radio Families were the first equipments that have been produced by ASELSAN for the military forces. The accumulated knowledge was gained during the production of this first radio family. The well-trained engineer forces opened the way to meet the other needs of the Turkish Armed Forces. As a company policy, ASELSAN used foreign technology transfer to develop its standards and achieve original design equipments. For instance; 4600 VHF/FM Radios were produced by technology transfer; and this lead to the production of the improved 9600 VHF/FM Frequency Hopping Radios (Annual Report, 2000). The “History and Events” in ASELSAN over the years is given in the Appendix-C.

5.3. The Organizational Structure and Defining the Divisions

The organizational structure was divided into three divisions in 1991; Communication Division, Microwave and System Technologies Division and Microelectronic and Electro-Optic Division. Figure 5.4 represents the organizational structure of ASELSAN.

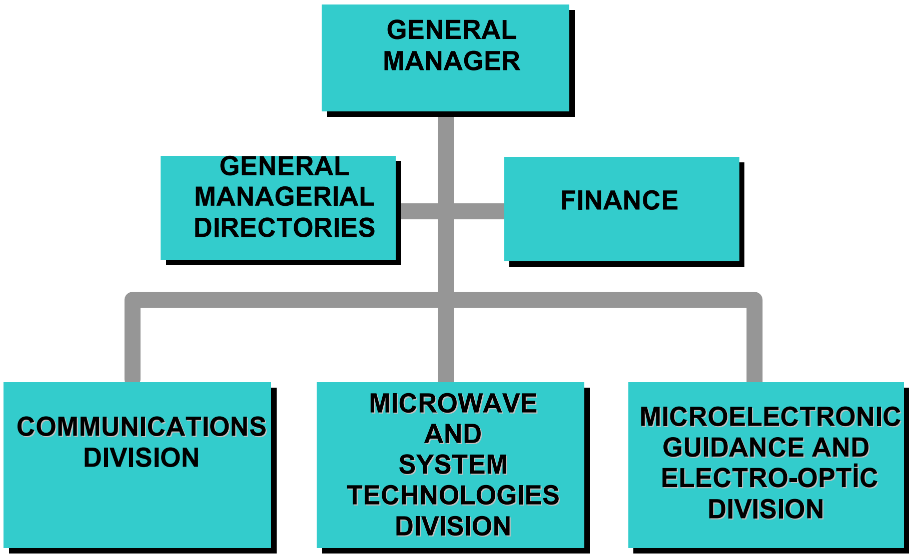


Figure 5.4. Organizational Structure of ASELSAN (Source: Internal Data, 2003)

The Communications Division and **Microwave and System Technologies Division** have high technology and automated infrastructure in engineering and production at Macunköy facilities. Electronic production includes surface mounting technology, multi-layer and flexible printed circuit boards, mechanical and mould productions, system integration and test fields. While Communications Division's main product spectrum covers military and professional communications systems, Microwave and System Technologies Division's main operations are focused on radar, electronic warfare and command-control systems, making these divisions evolving technology centers in their fields. Equipped with high technology engineering, automatic production and test equipment, **Microelectronics Guidance and Electro-Optics Division** manufactures hybrid microelectronic circuits, night vision equipment, thermal cameras, laser ranger/designators and inertial navigation systems at Akyurt facilities (www.aselsan.com.tr).

5.3.1. Communications Division

Communications Division is managed by ten Directories as shown in Figure 5.5; Production Directorate, Mechanical Design Directorate, Facilities Management and Construction Directorate, Planning Department, Avionic Communication Department, Training Department, Project Department, Marketing Directorate, Engineering and Product Quality Directorate, Sales and System Installation Department. Communications Division produces equipments with the following capabilities;

- Electronic Product /System Design and Mechanical Design capabilities.
- Printed Board and Mechanical Parts Production, Electronic Production and Testing capabilities. CAD-CAM applications are used widely in all activities.
- Effective Management Data processing system and MRP II are used widespread.
- Total Quality Management, System Engineering and Project Management are the techniques used in all activities.
- In-production and environmental testing facilities are qualified with respect to the highest level of standards.

Core Technologies used by the Communications Division are Mobile Radio, wireless Voice and data networks, switching, Packet switching, Spread Spectrum, TMN (Telecommunication Management Network), Encryption, System Integration, and AC Drives.

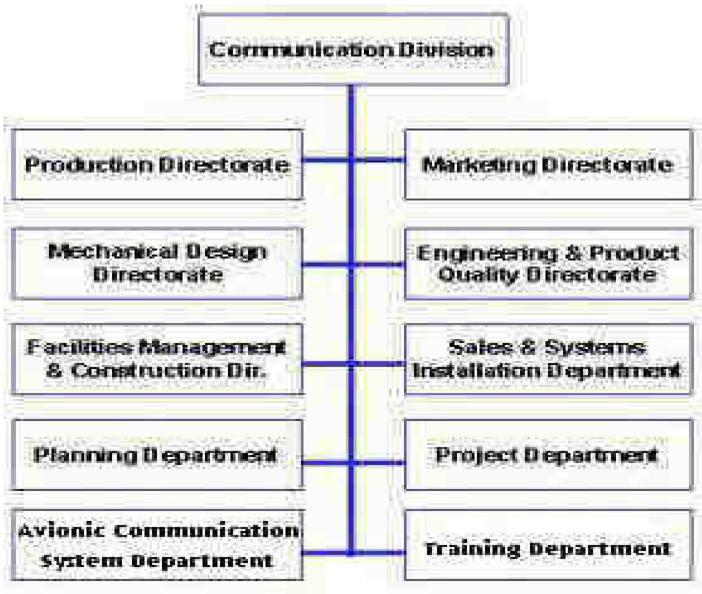


Figure 5.5. Organizational Structure of Communications Division (www.aselsan.com.tr)

The following features are utilized in terms of **Engineering**-base**:**

Analog Circuit Design, Digital Circuit Design (ASIC, PLD, FPGA), Microwave and RF Design, Microprocessor HW and SW Design, High Level SW Design, DSP Design, Mechanical Design and Prototype Fabrication, Software, Hardware and Mechanical Computer Aided Design and Simulation Environment AC Drive Product and System Design.

5.3.2. The Microwave and System Technologies Division (MST)

The organizational structure of MST is shown in Figure 5.6. Four Department and five directorates manage this Division. These are: Quality Assurance Department, Market Development, Financial Analysis and Planning Department and Electronic Warfare Programs Directorate, Defense Programs Directorate, Engineering Directorate, Production Directorate, Management Support and Operations Directorate.

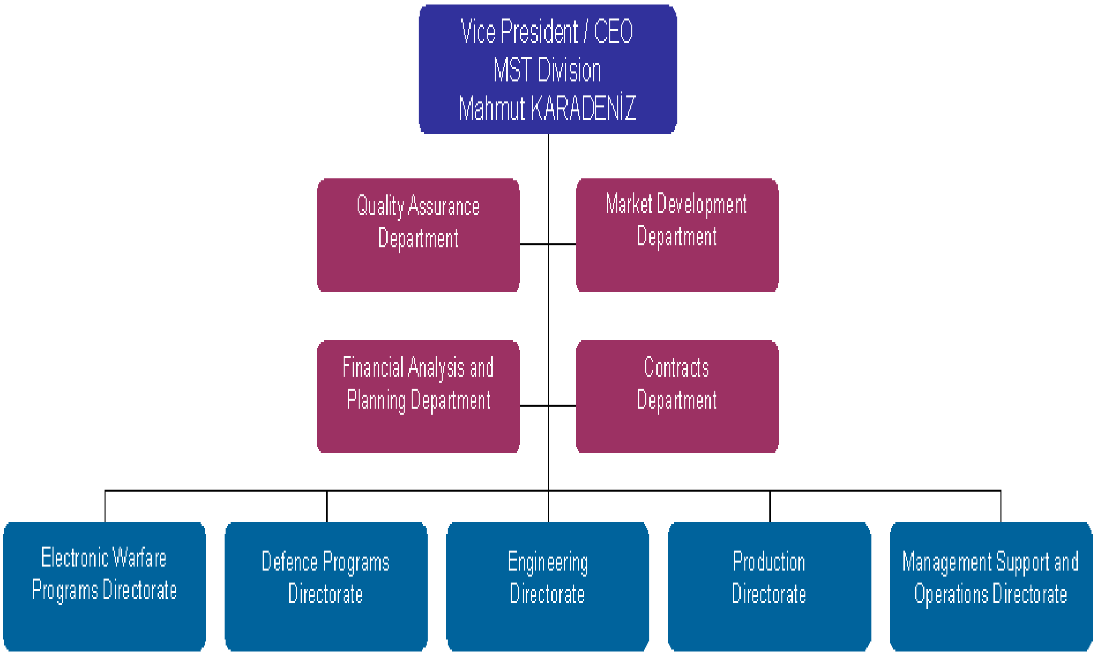


Figure 5.6. The Organizational Structure of Microwave and System Technologies Division (www.aselsan.com.tr)

MST Division designs, develops, manufactures and integrates; sensor, command and control, communications and counter measures sub-systems and equipment for land, navy and air platforms. It also provides military grade integrated logistic support services to its product throughout the life cycle of the equipment. The field of activities are as follows: Electronic Warfare and Intelligence Systems, Radar Systems, Defense and Weapon systems and Command and Control Systems and Automation Systems.

MST Division produces Highway Emergency Communication and Control Systems, Automatic Toll Collection Systems, Highway Observation systems and Traffic Control Systems. Total Quality Management implemented through Process Improvement Teams improves all Process of the MST Division. The national Frequency Spectrum Monitoring System Project is another important application of MST Division.

5.3.3. Microelectronics Guidance and Electro-Optics Division (MGEO)

The organizational structure of MGEO is shown in Figure 5.7. This division is directed by; Marketing and Sales Directorate, Product Assurance Directorate, Human Resource and Support Services Directorate, Production Directorate, Engineering Directorate and Planning Directorate.

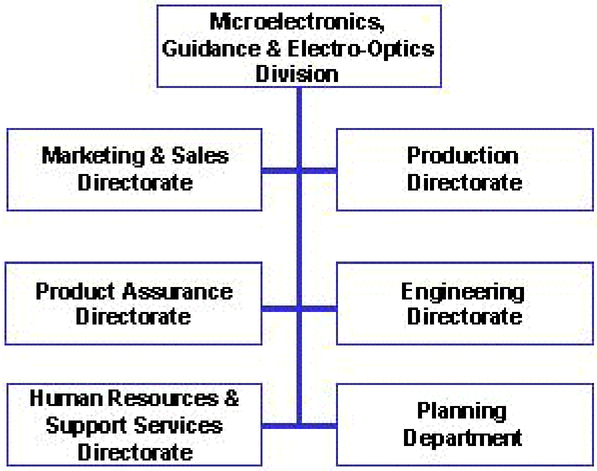


Figure 5.7. The Organizational Structure of Microelectronic Guidance and Electro-Optics Division (www.aselsan.com.tr)

The ASELSAN Microelectronics, Guidance and Electro-Optics Division which operates in Akyurt, focuses on core technologies related to Hybrid Microelectronics, Electro-optics, Guidance and Navigation which are strategically important and representing the most critical technologies of today. Equipped with high technology engineering, automatic production and test equipment, projects are being carried out in Hybrid Microelectronics, Inertial Navigation, Infrared Guidance, Laser Guidance, Thermal Imaging, Passive Image Intensifiers, Target Acquisition, Laser Generators and Sensors.

The MGEO Division located in the Akyurt Facilities, designs and manufactures products and systems in Electro-Optics, Guidance, Inertial Navigation and Hybrid

Microelectronics The MGEO Division provides our Country and the Turkish Armed Forces with technologically advanced products. It has a total staff of 656, people including 233 engineers. In this context, various projects in the areas of Thermal (IR) Imaging, Passive Night Vision, Inertial Navigation, Guidance, Laser and Hybrid Microelectronics are being carried on.

Keeping the Research & Development (R&D) project work in the forefront, developing new equipment and systems by means of advanced technology and being close observers of the fast developing technology have always been amongst ASELSAN's aims. The MGEO Division successfully continues to provide technologically advanced products, within its scope of activity. The Engineering Department of the Division with 115 engineers, 4 specialists, 5 consultants, 12 technicians and 4 administrative personnel, not only produces new designs, but also adopts existing systems to new platforms and carries out the design changes necessary for this purpose. In doing this, the aim of the Department is to create an integrated design environment (electronic, mechanical, and software) and apply a top-down design approach using concurrent engineering methodology.

The management style is horizontal and the maximum employee satisfaction is sought through Total Quality Management. Subcontracting is preferred whenever possible from both foreign and domestic sources with the purpose of following the technology worldwide and encouraging small businesses in Turkey.

The design and development mentality is to incorporate the recent techniques leading to shortest possible design cycle and to products with maximum lifetime. New materials are introduced to design as soon as possible and development work is continued after the first commissioning through evolutionary acquisition. Computer Aided Engineering (CAE) and Computer Aided Manufacturing (CAM) tools supports design and development.

Manufacturing: The existing investments were used to the maximum extent and efficiency was taken into consideration. Restructuring towards Flexible Production Systems, which make it possible to produce new equipment and systems with a minimum amount of investment, was continued and the following activities were carried out:

- Production and Testing of Thermal Equipment.
- Production and Testing of Image Intensifying Equipment.
- Production and Testing of Image Intensifying Tubes.
- Production and Testing of INS Equipment (LN39, LN93, LN100G).
- Production and Testing of Gimbals Platforms.
- Production and Testing of Laser Range Finder and Designating Equipment.
- Ability to Perform Tests of Environmental Conditions Conforming to MIL STD 810 (Heat, Vibration, Shock, Carrying, Heat/Humidity/Pressure, Heat/Vibration, Rain, Dust, Plunging).
- Production and Testing of Chip & Wire Hybrid Microelectronic Assemblies.

In all divisions, methodologies complying with military standards and ISO-9001 are successfully applied using computer-aided design (CAD), computer aided engineering (CAE) and computer aided manufacturing (CAM) technologies.

5.4. Technology Policy of ASELSAN

Acquiring technology has been the one of the main priorities of ASELSAN (Electronic Industries Inc) since its foundation. The acquiring technology period starts to take a step relating technology areas with the way, either technology oriented R&D studies, or technology transfer. The further period can be summed up with assimilation, transformed into product, development of products and the design of the derivative products. ASELSAN benefit from technology transfer as a sub-component to support acquiring technology period (ASELSAN magazines, special issue, 1999).

Since the technology policies of the industrial institutions in Turkey is generally in the form of purchasing a separate production technology or establishing a partnership with a technology-possessing foreign firm for each production they are to realize; there is almost no other leading defense industry institution other than ASELSAN that manufactures products based on original technology.

Original technology means, highly competitive power as a country, advancement in science and technology, actual/real industrialization, a strong economy, social prosperity, dissuasiveness of the defense systems, and the improvement of the national self-esteem.

The electronics technology being the main field of ASELSAN is a **generic** technology. It is utilized in almost every field from medical to musical, telecommunications to weaving looms and automotive and machinery manufacturing industries such as transportation equipment/devices, etc. Therefore, nationally original electronics technologies developed for defense systems, can contribute to the economical development of Turkey by application to sectors other than defense industry.

The importance of electronic technology in the defense systems is vital. The defense system technologies are developed as per the improvement of speed and sensitivity, i.e., the one that is faster will win the war. The technology that provides the speed and sensitivity to the defense systems is the electronics technology. Aselsan is currently the leading firm in Turkey that develops national electronics technology with its “original technology development” policy, that is applied nationally in Turkey for the first time, to the software, critical electronic hardware and digital electronic technologies that constitute the sub-technologies of electronics and that operate the defense systems. (Zaim, 2001a, 2001b and Ziylan, 2000)

5.5. Sales, Export, Human Resources and R&D

5.5.1. Sales

As seen in Figure 5.8. the total Sales is 2.3 Billion $ in between the years 1980-2002. The sales to national sources amount to 1.9 Billion $ (Turkish Armed Forces and Other Sales), whereas the Export sales is approximately 0.4 Billion $ (17%).

Figure 5.8. Total Sales Distribution in Years 1980-2002 (Source: ASELSAN Internal Data, 2003)

In the following figure (Figure 5.9), the sales of ASELSAN among the years 1982-2002 has been graphically illustrated and as can be seen, the sales up to 1991 has shown a slow upward trend, after which the sales climbed in a sharper format except for 1994, where the effect of economic crisis can be clearly observed.

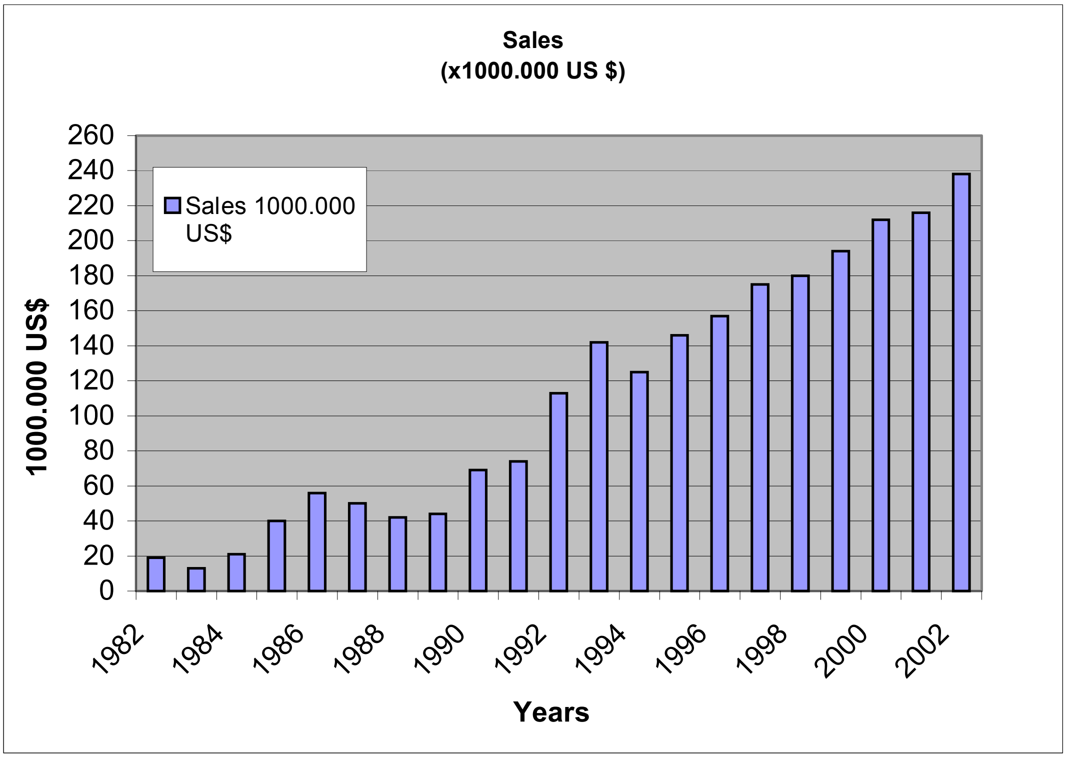


Figure 5.9. The Graphical Illustration of Sales in ASELSAN (Source: Internal Data, 2003)

5.5.2. Exports

The technological capabilities of ASELSAN in military and professional electronics have been internationally accepted. ASELSAN exports amount reaches approximately to 17% of its total sales. ASELSAN's first export activity was realized in 1983, and it has been continued successfully every year. ASELSAN has been exporting its high technology products to 23 different countries including USA, Germany and Switzerland. The graphical illustration of the exports realized between 1994-2001 is given in Figure 5.10.[15]

[15] See Appendix E for Aselsan's export product development in years, 1983-2000.

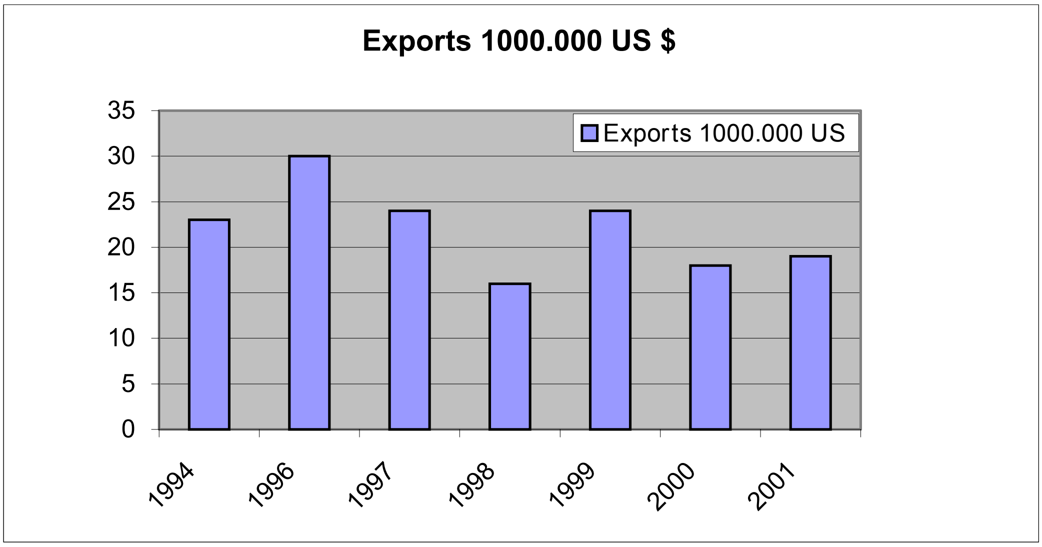


Figure 5.10. The Graphical Illustration of Exports in ASELSAN (Annual Reports 1994-2001)

5.5.3. Human Resources

In ASELSAN, qualified work force is accepted as the most important factor of the infrastructure. Therefore great importance has been attached to the work environment, which encourages expertise, in-house training, development and creativity. Hacim Kamoy[16] claimed that "Investment made in people and knowledge lies at the bottom of ASELSAN's success"(Annual Reports, 1999). Table 5.1 shows the current situation regarding the number of personnel as by April 2003, and Table 5.2 displays the human resources in ASELSAN over years. Table 5.1. Shows that ASELSAN is currently employing a high percentage of qualified personnel including engineers, university graduates and technical personnel, which totally amount to approximately 80% of the total personnel. As seen in Table 5.2, the percentage of R&D engineers in the total number of engineers is approximately 50-60 % in the years 1994 -2001.

[16] Hacim Kamoy has been the director of ASELSAN in the years 1976-2000.

Table 5.1. Human Resources in April 2003

Human Resources	Number	**% of Total**
Engineers	486	16,66
R&D Engineers	580	19,88
Other University Graduates	217	7,44
Office Personnel	216	7,40
Technical Personnel	1059	36,29
Personnel	315	10,79
Temporary Personnel	45	1,54
Total	**2918**	**100**

Source: Internal Data (April 2003)

Table 5.2. Human Resource in ASELSAN Over Years

	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
# of Engineers/Total Personnel	22%	24%	26%	28%	29%	32%	33%	34%
# of R&D engineers/# of Engineers	50%	53%	55%	56%	57%	57%	59%	60%

Source: Annual reports and internal data, 1994-2001

Figure 5.11 below, shows the percentage of engineers in total, between the years from 1976 to 2000. As seen in the figure, the number of personnel and engineers decreases seriously in the 1990-1994 period. There might be two reasons behind this; first of all, in 1991 ASELSAN was organized under three divisions regarding the projects within the field activity. This reorganization might have required new organizing principles about human resources. Secondly, when Turkish economy is taken into consideration, it is seen that 1994 has been a difficult economic period including the economic depression in Turkey and its consequences might have contributed to the decrease in the number of personnel.

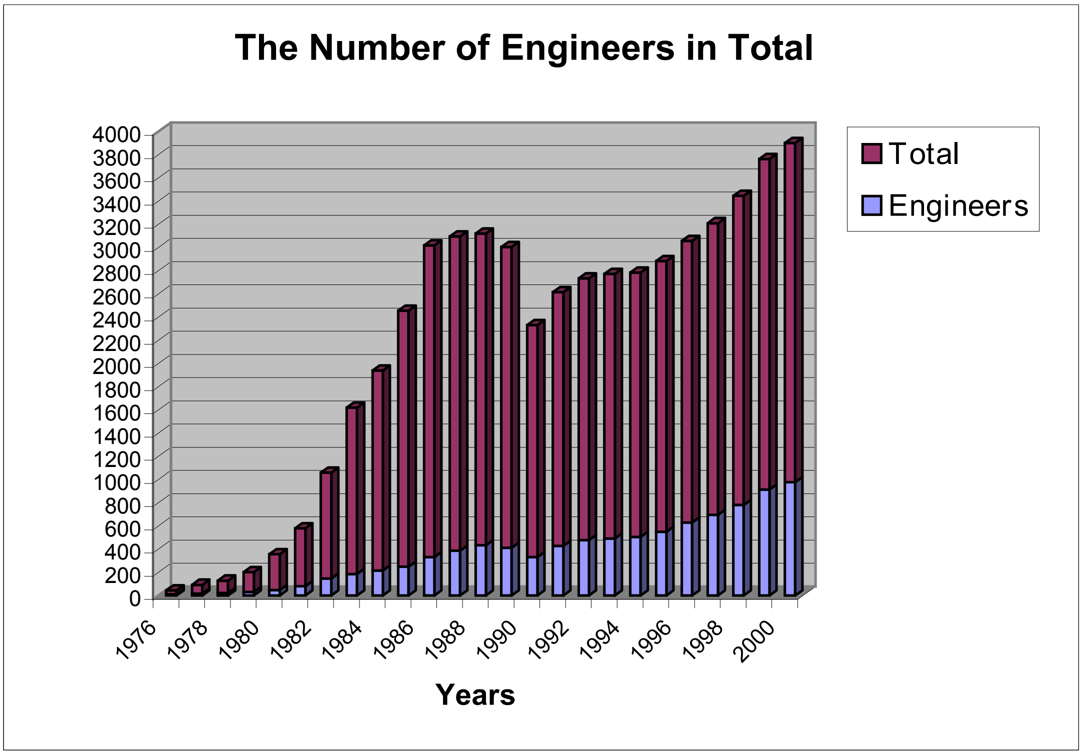


Figure 5.11. The Number of Engineers Compared to the Total Number of Staff Among Years

5.5.4. ASELSAN and R&D

The important element of industrialization is producing technology. The industry that is not based on the original technology is dependent upon foreign sources and does not have a competitive characteristic. Moreover, as for Defense industry, systems produced not have dissuasiveness.

The companies, using foreign technology, that have been founded as a result of the industrialization policy commenced in 1980s, which is based on exports, have started to establish their own R&D units and develop their own technologies; since there is no other way of possessing high-technology and being competitive in the international markets.

Technology provides great advantages to the possessor. Since no one would desire to transfer this power, it is not possible to acquire the high design technology by means of procurement. The technologies being the subject of sales are generally not design, but production technologies. Since the advanced technologies regarding the defense systems are under the control of the governments, not the companies, it is generally very difficult to acquire these via partnership or purchasing. Therefore, the only way of attaining a competitive power and ensure dissuasiveness at the defense systems is the production of technology by the national companies and institutions. Since the day it was founded, ASELSAN has applied a policy in which products are produced with the original technology developed by its own engineers, and that has the competitive capability in the worldwide markets, and therefore always has invested in human resources. As a natural outcome of this practice, ASELSAN has succeeded in designing and producing high-tech devices/equipment and systems concurrent with the leading western firms, and it has been granted various awards due to its R&D studies.

ASELSAN's research and development (R&D) activities are the induced characteristic of ASELSAN's acquiring technological capability and achieving the target of being internationally competitive through development of core technology. As a general company policy, R&D expenditures are fixed at 8% of total sales that amounts to approximately **13 million $/year R&D expenditures**.

Figure 5.12 shows the R&D expenditures in ASELSAN among years and the effect of 1994 economic crisis can again be observed in this figure. This figure has the same trend as of Figure 5.9, displaying the Sales, since the R&D expenditures, as explained above, are fixed to 8% of the Total Sales.

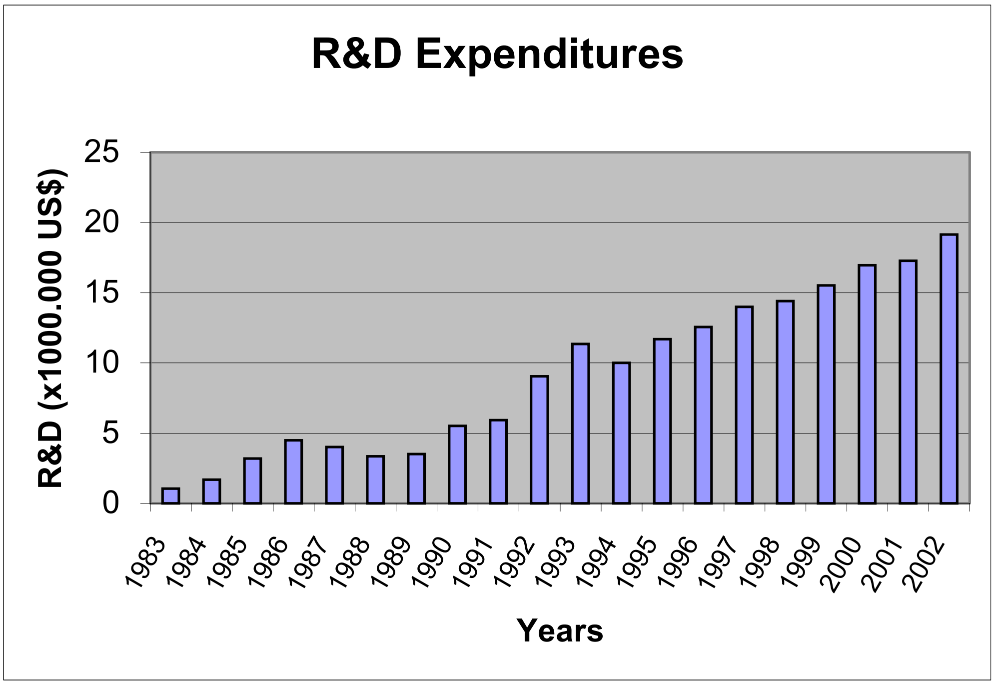


Figure 5.12. R&D Expenditures in Years (Internal Data, 2003)

There is no need to discuss the point that R&D process is an expensive and hard period for the individual firm. The only way necessary for receiving back the investment of R&D is to supply/present the developed products to the market; namely to sell them.

When the ratio of R&D expenditures of ASELSAN is compared with the firms from European countries' expenditures, it is clear that it is placed well above various eminent firms like Siemens, Bosch, Alcatel, etc. (Table 5.3).

Table 5.3. Europe's R&D Expenditure League (1996)

Rank Company	R&D as a % of Sales	Industrial Sector
Roche Switzerland	15.3	Pharmaceuticals
Ericson Telefon Sweden	14.1	Telecommunications
Glaxo-Wellcome UK	13.9	Pharmaceuticals
Novartis Switzerland	10.1	Chemicals
Rhone-Poulenc	9.4	Chemicals
Siemens	7.7	Electronic and
Aesa Brown Boveri-Switzerland	7.6	Engineering
Hoechst Germany	7.6	Chemicals
Bayer-Germany	7.4	Chemicals
Robert Bosch Germany	7.0	Electronic and electrical equipment
Alcatel Alsthom	6.9	Telecommunications
Phillips Netherlands	5.9	Electronic and electrical equipment
Volvo Sweeden	5.3	Engineering and vehicles
Daimler-Benz Germany	5.2	Engineering, vehicles
Renault France	5.0	Engineering vehicles
BASF-Germany	4.7	Chemicals
Volkswagen-Germany	4.0	Engineering, vehicles
Peugot France	3.6	Engineering and vehicles
Fiat Italy	3.0	Engineering and vehicles

Source: Trott, 1998

ASELSAN's Research and Development activities accelerate with the intranets application system. The infrastructure of the network system includes as follows: (2003, internal data):

- **4 computer networks**
- **2245 terminal**
- **580 CAD/CAM work Station**
- **MANMAN software**

5.5.5. Collaboration with University

Collaboration with university is important in development of firms in industry and Figure 5.13 shows such benefits of collaboration of university and industry. The internship mechanisms, being an important factor in the development of both, have been carried out successively in ASELSAN.

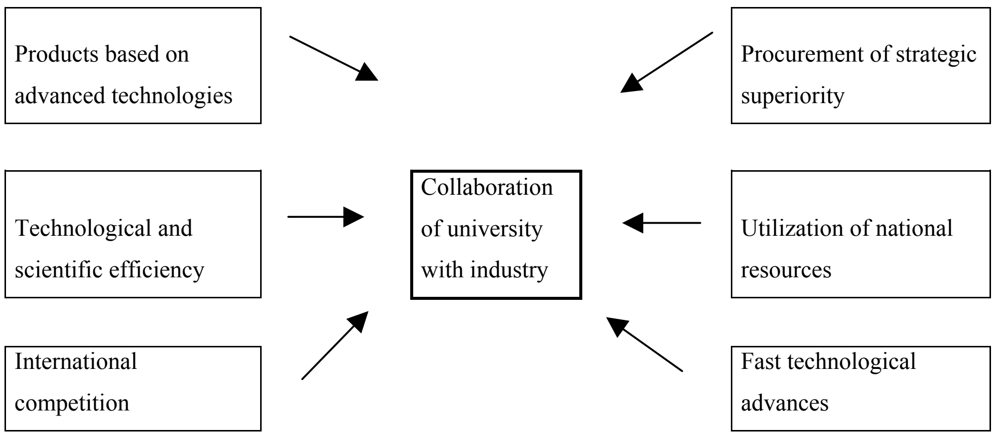


Figure 5.13. Benefits of Collaboration of University and Industry (Baktır, 1998)

A “Temporary Technical Personnel” mechanism was established and it was aimed at training students with regard to industry applications during their bachelor’s degree. Term projects were undertaken by fourth year students directed similarly to graduate thesis, and it was aimed at providing student with an accumulation of theory and practical knowledge regarding to the scope of ASELSAN's activities.

Since ASELSAN believes that R&D activities can be successful only with qualified and highly educated personnel, the firm has always supported its personnel during their graduate/post-graduate studies.

In the consortiums, universities take a role either directly or through firms they establish, they reach the opportunity to direct the project by providing recommendations a say in the financial and administrative responsibilities of the project "Turkish Armed Forces Command Knowledge Systems" is carried out by a consortium consisting of ASELSAN, TUBITAK-MAM (The Scientific and Technical Research Council of Turkey-Marmara Research Center, METU (Middle East Technical University) and STM (ATOS).

5.6. The Target of ASELSAN

ASELSAN's mission is to become a foremost leading institution in its domain by improving the successful status gained within the country and abroad, and as a straightforward and a reliable company to obtain customer satisfaction at home and throughout the world.

It has an effective and wide spread sales and service network in different provinces which serves to determine the requirements of customers on the correct location & time and enhance the customer satisfaction continuously, together with the after-sales services. In this context, the ultimate **objectives are**[17];

- To realize exportation in high technology products by achieving the level of competitive capability both in terms of quality and price in international markets.
- To balance the production between military and professional electronic products and thus obtain ASELSAN's continuity and development under every condition.
- To provide the necessary potential, to realize the production for the topics that ought to be national like electronic warfare, encryption and critical software.
- To be a technology center that can produce and design military/ professional electronic products and systems in the determined operating fields.
- To give primary importance to R&D studies.
- To maintain technology based planned and healthy growth.

[17] Summarized from www.aselsan.com.tr

- To obtain maximum customer satisfaction for each product and to comply to international quality standards.
- To provide a peaceful and secure working environment and in direction of the company objectives of ASELSAN for the personnel.
- To devote social values and commercial ethics, and to preserve the customer rights and the natural environment while realizing the company objectives.

5.7. ASELSAN's Product Innovations

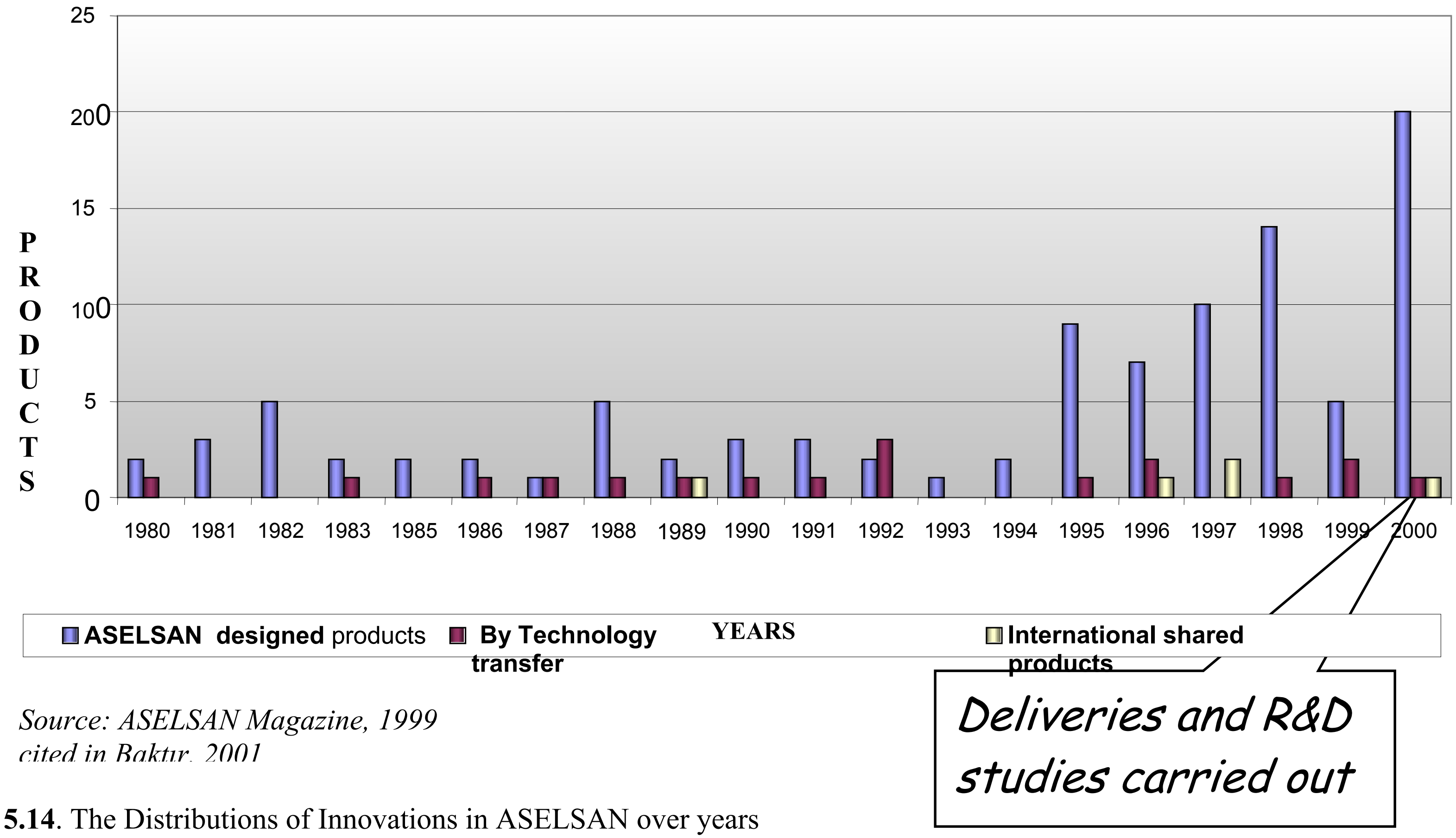
Table 5.4 and 5.5. shows the distribution and percentage, respectively of the products designed by ASELSAN in total production. As seen in the Table 5.5. this percentage increased up to 50% in 1998 where it seems to have stabilized until the year 2000. The graphical illustration of Table 5.4. is given in Figure 5.14.[18]

Table 5.4. The Distribution of Innovations In ASELSAN

Years	**Innovations Designed by ASELSAN**	**Innovations Designed by Technology Transfer**	**Innovations Designed by International Projects**
1980	2	1	-
1981	8	-	-
1982	7	-	-
1983	2	1	-
1984	-	-	-
1985	2	-	-
1986	2	1	-
1987	1	1	-
1988	5	1	-
1989	2	1	1
1990	3	1	-
1991	6	1	-
1992	2	3	-
1993	1	-	-
1994	7	-	-
1995	11	1	-
1996	9	2	1
1997	10	-	2
1998	14	1	-
1999	5	2	-
2000	14	-	3
2001	15	1	-
TOTAL	**128**	**18**	**7**

Source: ASELSAN Special magazine, 1999 and internal data, 2003)

[18] See Appendix D for further information for ASELSAN's products innovation.



Source: ASELSAN Magazine, 1999
cited in Baktır, 2001

Figure 5.14. The Distributions of Innovations in ASELSAN over years

Table 5.5. The percentage of product designed by ASELSAN in total production

Years	Products designed by ASELSAN/ Total Production
1995	32%
1996	31%
1997	40%
1998	50%
1999	52%
2000	49%
1980-1999 average	**39%**

Source: Internal data ASELSAN cited in Baktır, 2001

5.8. New Product Development

This section gives the information about the new product development strategies in ASELSAN in order to form a basis for the following sections and learning mechanism of this firm. Data obtained for team model and project directory belong to MST Division. Figure 5.15. gives the organizational structure of Project Directory in MST Division.

5.8.1. Design and Technological Capability

Regarding the Design and Technological Capability, Top Performers;

- Have mastered the fundamentals of managing projects (project management).
- Create product strategy that ensures an increasing number of products while simultaneously decreasing the number of platforms on which new products are based (our project directorates, product roadmaps, and customer relationship, requirement analysis, concept design, etc).
- Manage development pipelines to optimize the use of scarce development resources (our design process and reuse).

- Manage their technology development activities to maintain investment in the critical differentiators that make their products unique).

According to Baktır (2001), they need multi disciplinary teamwork and system engineering to create new products. Also they should make creativity and innovation is a part of their culture. Innovative, multi-disciplinary, teamwork culture and system engineering approach (team work)[19]

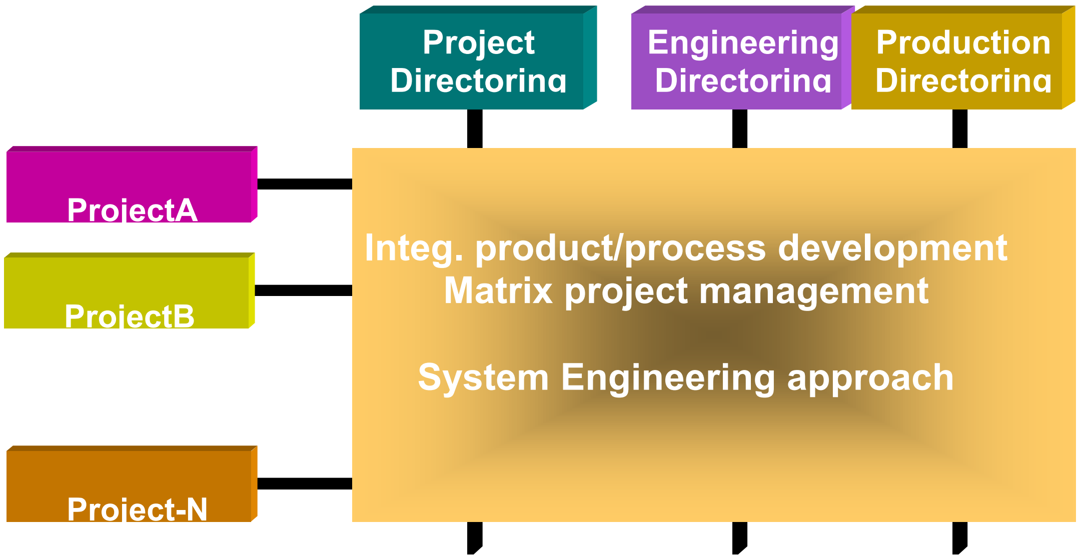


Figure 5.15. Organizational Structure of Project Directory in MST Division (Baktır, 2001)

Design of a product is fulfilled with the all disciplines represented in Figure 5.16; Technology Management, Project Management, System Engineering, Mechanic, Hardware, Software, Test, Design Checking.

[19] Summarized from www.prtm.com

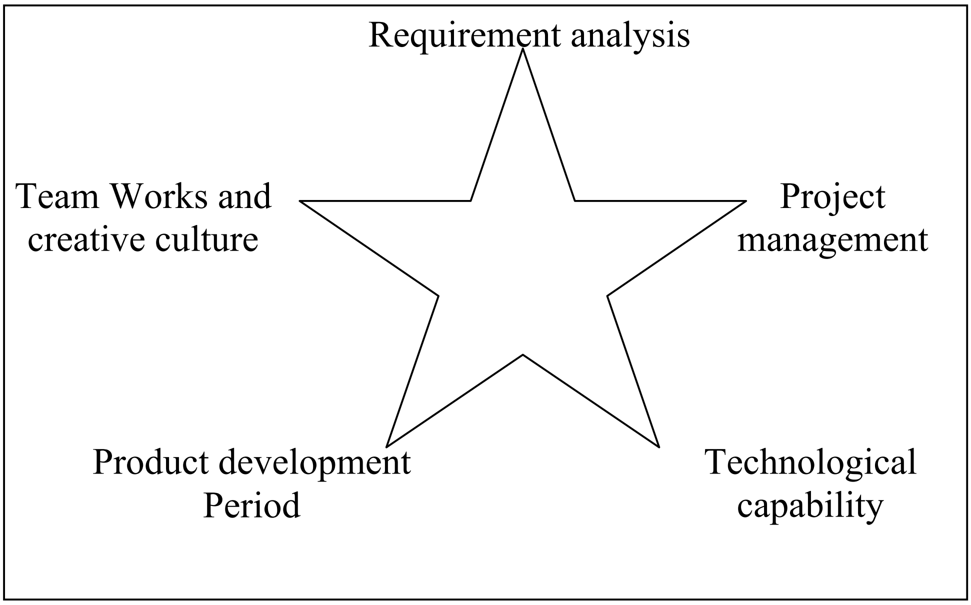


Figure 5. 16. Design of Technological Capability in ASELSAN (Baktır, 2001)

5.9. Technology Teams Model in ASELSAN

5.9.1. Technology Management

Technology management focuses on developing new technologies through initiating and monitoring individual technology development projects based on a clearly defined and communicated technology strategy. Technology strategy is to align investment decisions with the strategic direction of organization. Technology investment should be balanced between research, defensive (incremental) research and offensive (radical) research.

Management can be classified as below:

- Technology management
- Product Management
- Project Management
- Process Management
- Source Management

- Customer and Requirement Management
- Team Work Management
- Design Management

Designing a new product requires integrated components that include technology management, project management, design guarantee, system engineering, mechanic, software, hardware and test. It is important that collecting all components of design focusing on development of a new product in an integrated structure.

Management of Core technologies increasing competitiveness is directed with engineer charged with functional task and professionals with the subject and master thesis.

Long-term strategic works are managed collaboration with university, R&D project, technology transfer and master thesis

Short-term development of technology works are managed with team works, Internet, book, participation in Exposition-exhibition, periodicals, participation in abroad and seminars/conferences, different type of educations

Technology Management has the following tasks in ASELSAN:

1-Technology Portfolio: preparing the new product application matrix (which technologies are used, which projects, which technologies are needed in the new project areas considered, listing of required and absence technologies in ASELSAN)

2-Determining the seven dimensions that affects on every technology areas (functional performance, user-friendliness, cheapness, management, cost, reliability, care facilitation, suitability evaluation, determining of core technologies)

3-Existing infrastructure Evaluation: Technology (investment) inventory update and determination of technological capabilities

4-Evaluation of difference: which technologies are needed and the degree of criticism, the determination of the infrastructure presents in the new project considered.

5-Forming New Technology teams for the new technologies, supporting working applications. Additionally, the coordination among the teams is realized.(Baktır, 2001)

5.9.2. Core Technologies

The core technologies being ‘defense programs’, ‘electronic war’, ‘radar’ and ‘command control’ form together the matrix of the System Architecture, which is based upon the interaction, and contribution of software, hardware, mechanics and the system as a whole (Figure 5.17).

The core technologies are examined in core research, defensive research, and offensive research.

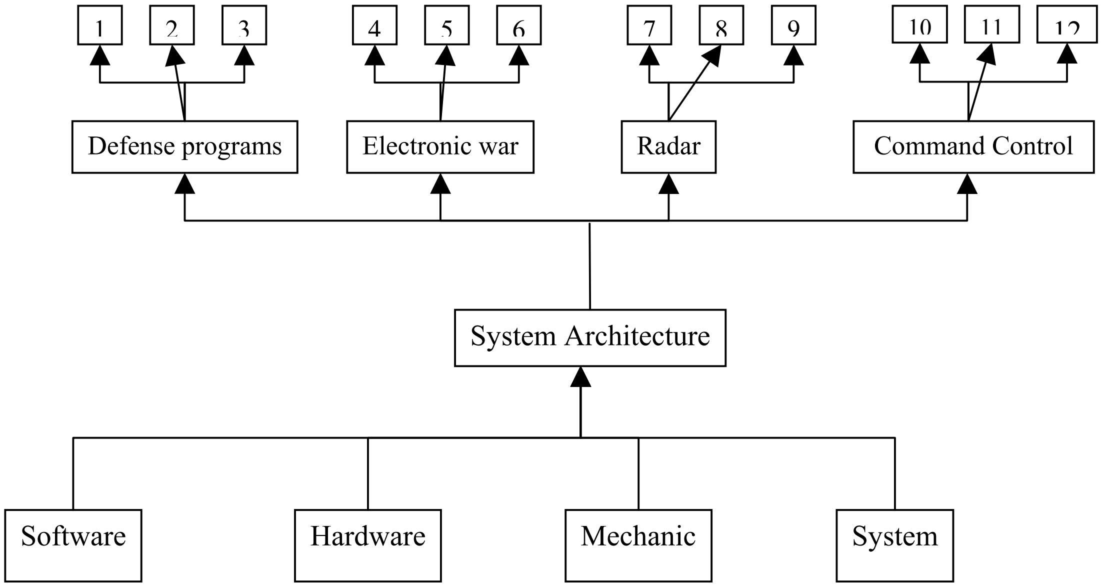


Figure 5.17. Core Technologies in ASELSAN (Baktır, 2001)

Core research focuses on developing technologies that will be used over a wide range of products or product platforms and which are considered a major source of competitive advantage. (The technology development work, which are conducted with our advisors from universities)

- Master thesis in different subjects
- Antenna design
- Microwave design
- Algorithm design
- Signal processing
- System engineering
- Project management
- Design and Integration Process
- SW & HW design (real time, packaging, miniaturization, ...)

Defensive research protects the future of an existing business by focusing on incremental technology development.

- Technology teams

Offensive research develops breakthrough technologies used to create new business in new markets.

- Research projects (supported by us, given to universities engineering analysis and solutions, EW)
- Technology transfer (Radar, radio)
- Master thesis
- Internal research projects (frequency hopping, radar)
- Receiver design

5.9.3. Technology Monitoring

Innovation frequently depends upon the convergence of advances in several technologies and the period between the emergence of a technological advance or a new technology and its practical application may span a number of years (usually 20 for scientific invention). Well-informed judgment and insight are also important. Managers receive their information inputs haphazardly reading, discussions, conferences and so on. If judgment is to be based upon good and comprehensive information, the gathering of these inputs should be organized so far as possible. Bright (1968 cited in Baktır, 2001) has proposed monitoring the environment on a systematic basis: "Monitoring includes much more than simply scanning. It includes search, consideration of alternative possibilities and their effects and a conclusion based on evaluation of progress and its implications. The feasibility of monitoring rests on the fact that it takes along time for a technology to emerge from the minds of men into economic reality, with its resulting social impacts. There are always some identifiable points, events, relationships and other types of signals along the way that can be used in an analytical framework. If a manager can detect these signals, she should be able to follow the progress of the innovation relative to time, cost, performance, obstacles, possible impacts and other considerations. Two important inputs to his decision as follows:

1- Awareness of new technology and its progress

2-Some thoughtful speculations about its possible impact

The attraction of monitoring is that any individual manager for her own information can perform it. The richness of the information and the deductions are obviously enhanced if organized on a departmental or interdepartmental basis.

Technology monitoring department works on fundamental issues in Directories. These department responsibilities are forming and development of technological infrastructure of ASELSAN. This department is charged with (1) joining necessary seminars, exposition and educations, (2) researching knowledge sources and (3) obtaining the project considered with application.

Technology monitoring is directed by;

- Technology teams
- Following the developments with firm’s reports, evaluation articles or literature in specific technology areas, monitoring technology institutions, firm’s strategies, conferences, seminars, educations, studies in universities, following the technology management periodicals
- Application works
- Coordination with teams and seminars in firm
- Reporting the result

5.9.4. Technological Innovation Development and Diffusion Plan

Technological innovation development plan is shown in Figure 5.18. The technology teams direct the first three steps of technology innovation plan, and support the further steps. The main aim is to ensure the most accurate balance between the customer demands and the engineering solutions to meet these demands. The sample format of “Quality House” is shown in Figure 5.18 and the filled out form of this figure with an example is illustrated in Figure 5.19.

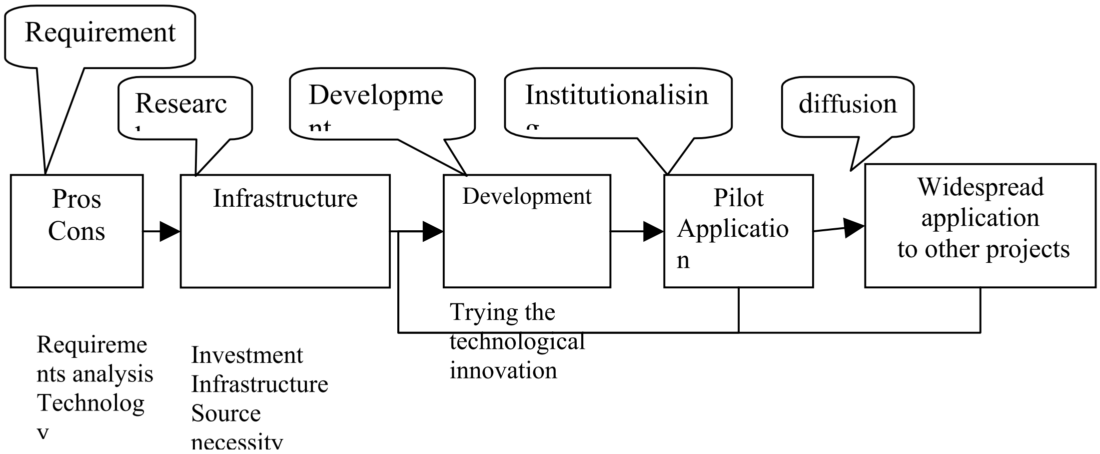


Figure 5.18. Technological Innovations Development Plan in ASELSAN(Baktır, 2001)

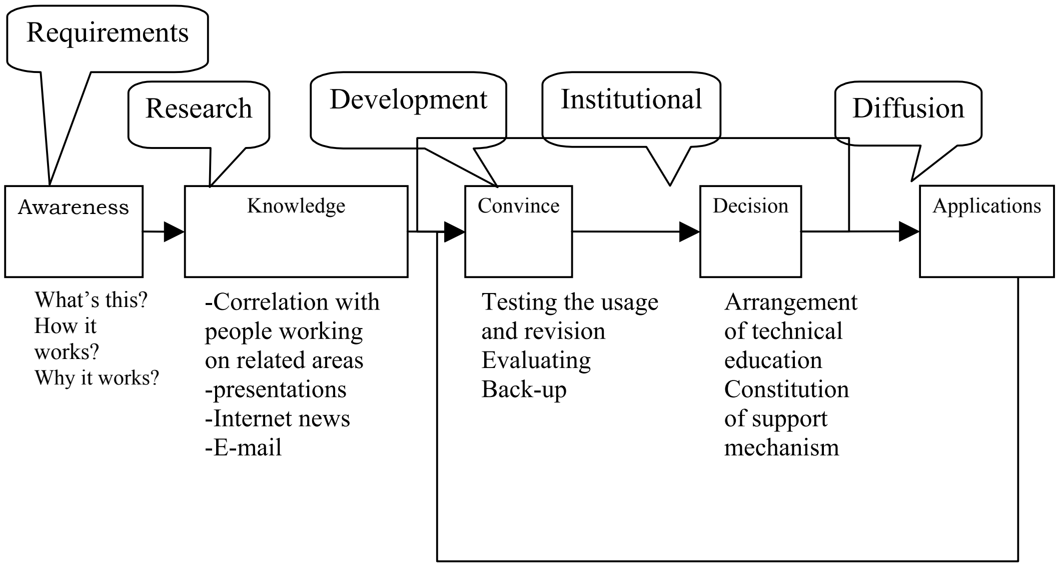


Figure 5.19. Technological Innovations Diffusion Plan (Baktır, 2001)

The evolutionary stages of technology production in ASELSAN, all the way from technology transfer & technology & knowledge accumulation to the final economic benefits, products and thereby, development is shown in Figure 5.20.

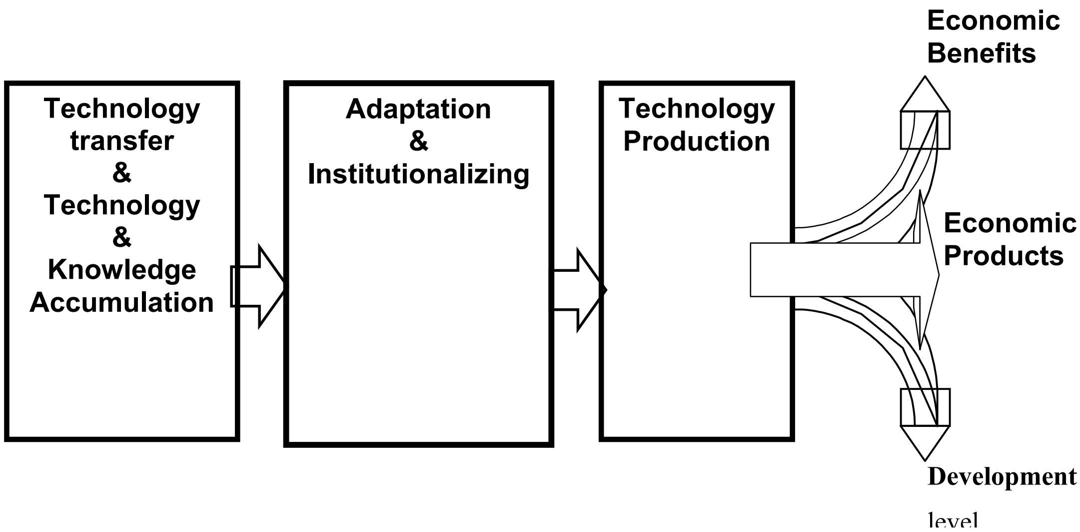


Figure 5.20. Technology Production in ASELSAN (Baktır, 2001)

5.9.5. The Working Principle of Technology Team

Engineering Technology teams working plan of MST division is shown in Figure 5.21. Technology teams Evaluation;

Conflict between the definition of work, starting date, forecasted finish date, output, target, the percentage of realization (coming true), the result, the number of personnel, approximate budget, realized budget, problems and absences,

Solution propositions/ the target of activity: Work definition, forecasted starting date, forecasted finish date, target and expected result, the number of personnel, approximate budget, risk areas, approach proposals.

Evaluation Creation: System Requirements/ Restriction Program Explanation, Performance Creation: Special technical performance creation related technology. Modularity, strength, Feasibility, productibility, extension, Maintainability, Safety, capacity, weight and volume, sensitivity to environment condition, real time , meeting requirement, suitability of the standards

Sources Program Explanation: The plan of acquiring technologies (acquisition, learning, trial period, Budget/Cost/price//Explanation, The cost of acquiring technology (all cost from the acquiring to learning period)

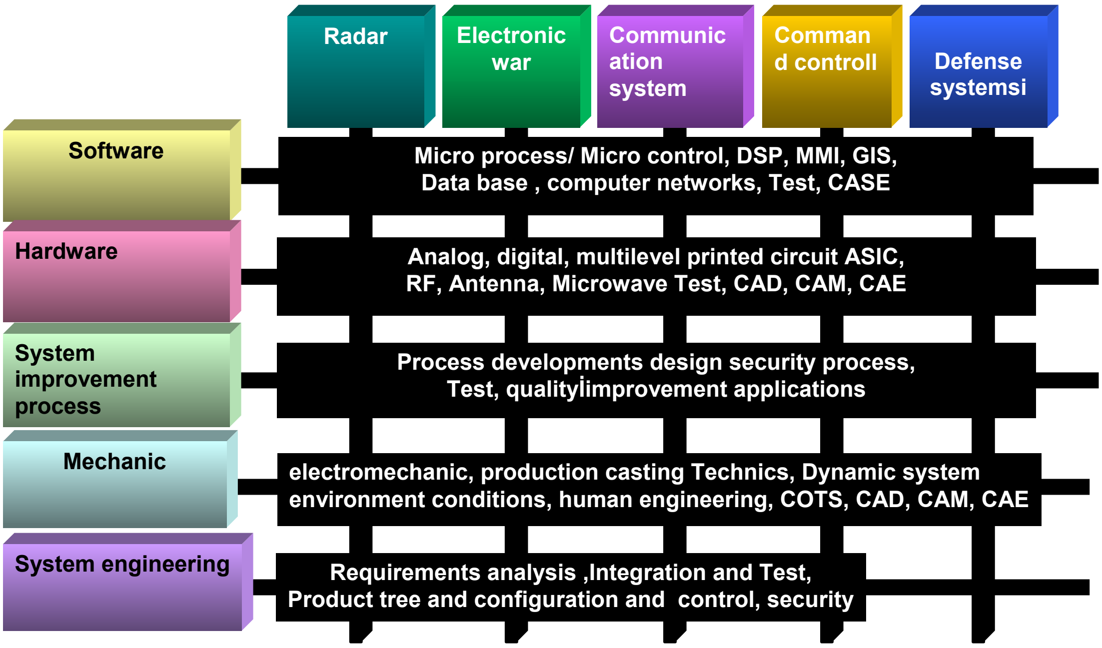


Figure 5.21. Engineering Technology Teams in MST Division(Baktır, 2001)

Human Resource: The importance and situation of the staff (having the control of technology team leader, functional and project managers):

- **Team Working**: Engineering management decides to found teamwork for study on specified task.
- **Every team** is defined as a name that determined relating technology. However, It could be included any engineering discipline or a few engineering area.
- **Work groups** founded with professions relating task for the aim of improving process, are accepted as a technology team.
- **Works** are directed and coordinated by technical director.

The balance of power between the project and functional areas is very delicate the movement of resources from technology team to technology team may foster political infighting. The division of authority and responsibility is complex, and uncomfortable for the technology team leader. Engineers have at least two bosses, their technology leaders and the project manager.

Advantages:

- Personnel are satisfied with improvement in their capability
- Knowledge sharing and possibility of re-using
- % 10 of work force are provided to focus on technology monitoring
- Solutions are produced for problems together
- The technology is the point of emphasis The technology could be reflected to the projects in all areas, and also it is possible to obtain requirements
- The organization allows a better company-wide balance of resources to achieve goals There is a great deal of flexibility in precisely how the project is organized within the matrix

5.10. Transformation of Technology in New Product Development: ASELSAN's Radio Equipments in 1980-2002 Period

This study analyses the transformation period of radio equipments and the institutional structure of ASELSAN during the period 1980-2002 (Table 5.6). The upper part of Table 5.6 shows the products by years that only process innovation is taken place. Bottom half of the table classifies innovations; design, production, using support, project management and engineering respectively. The common property of the products in the table is that they share the same technology or derivatives of others; for instance: mobile phone technology takes place in this table because its technology is correlated with other radio equipments.

Table 5.6 Transformation of Technology

Product Development	Types of Progr.	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02
PRODUCTS																								
4600 Military Radio Family	License																							
5600 Combat area Military radio Family	Development																							
9600 Freq. hopping military radio family	Org.																							
4200/4500 Fixed frequency Radio Family	Original R&D																							
4200/4500 Fixed frequency Repeater radio	Original R&D																							
4821/4825 Synthesized Vehicular Radio	License																							
4831/4835 Synthesized Base station	Development																							
4841/4845 Synthesized Repeater Station	Original R&D																							
4811/4815 Synthesized hand-held radios	Original R&D																							
4900 Series Trunk Radio family	Original R&D																							
4000 Series Radio Family	Original R&D																							
4100 Series Trunk Radio Family	Original R&D																							
1919 GSM Mobile Phone	Original R&D																							
1920 GSM Mobile phone	Original R&D																							
4400 Series Radio family	Original R&D																							
Design innovation																								
Fixed frequency (crystallized)/Multi- channel																								
Synthesized/Multi Channel Radio																								
Radio controlled by software																								
Radio controlled by software/programmed																								
Production innovation																								
Multi-layer Printed Circuit Technology																								
Surface mount technology																								
Application Specific Integrated Circuit tech.																								
Specific integration circuit technology																								
Using Innovations																								
Touch set																								
Screen																								
Graphic screen																								
Using Menu system																								

Table 5.6. *(continued)*	Types of P.	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02
4600 Military Radio Family	License	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5600 Combat area Military radio Family	Development												■	■	■	■	■	■	■	■	■	■	■	■
9600 Freq. hopping military radio family	Original R&D															■	■	■	■	■	■	■	■	■
4200/4500 Fixed frequency Radio Family	Original R&D		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4200/4500 Fixed frequency Repeater radio	Original R&D			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4821/4825 Synthesized Vehicular Radio	License				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4831/4835 Synthesized Base station	Development						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4841/4845 Synthesized Repeater Station	Original R&D								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4811/4815 Synthesized hand-held radios	Original R&D										■	■	■	■	■	■	■	■	■	■	■	■	■	■
4900 Series Trunk Radio family	Original R&D												■	■	■	■	■	■	■	■	■	■	■	■
4000 Series Radio Family	Original R&D															■	■	■	■	■	■	■	■	■
4100 Series Trunk Radio Family	Original R&D																■	■	■	■	■	■	■	■
1919 GSM mobile phone	Original R&D																		■	■	■	■	■	■
1920 GSM mobile phone	Original R&D																				■	■	■	■
4400 Series Radio family	Original R&D																					■	■	■
Support Innovations																								
Self Test									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Test connecting with computer												■	■	■	■	■	■	■	■	■	■	■	■	■
Electronic Book																■	■	■	■	■	■	■	■	■
Program Management																								
Project man. with centralized functions		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Matrix Project management																■	■	■	■	■	■	■	■	■
Engineering Innovations																								
CAD/CAE/CAM tools							■	■	■	■	■	■	■	■	■									
CASE tools										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Integration CAD/CAM/CAE/CASE tools											■	■	■	■	■	■	■	■	■	■	■	■	■	■
System Engineering Applications										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Quality of Software Security Applications											■	■	■	■	■	■	■	■	■	■	■	■	■	■

Source:internal data , author's design.

The chronology of innovative activities (see table 5.6) taken place in ASELSAN can be summarized as follows:

- Firstly, ASELSAN produced the first 4600 series military radio by technology transfer (license) while project management in functional diversification by product with centralized functions.
- In 1981, it produces 4200/4500 crystallized professional radio families by original design with learning-induced characteristic of R&D (Properties: crystallized / multi channel, centralized function management)
- In 1982, 4200/4500 repeater professional radio
- In 1983, 4821/4835 synthesized vehicle radio by technology transfer
- In 1985, 4831/4845 synthesized fixed center radios is the development product of license equipment. In two years, the learning period from technology transfer to imitation and development acquired. Firm started to use CAD/CAE/CAM tools for production and design.
- In 1986, started to produce surface mount circuit technology
- In 1987, 4841/4845 synthesized repeater hand held radio by original design, From the license to original design product, 1982-1987 period firm gained the capability of the production and design on the synthesized radio with the surface mount technology, self test, using CAD/CAM/CAE
- In 1989, 4844/4815 hand held radio by original design. In this year, printed circuit technology developed from surface application to specific integrated technology, self test CAD/CAM/CAE/additionally CASE
- In 1991, 4900 series trunk radio family by original R&D. Properties controlled by software, connecting with computer test, Integrated CAM/CAD/CAE/CASE system engineering application quality security.

In the military radio family-5600 sires with the properties controlled by software, tush set, graphic screen and integrated circuit technology, test by connecting computer, integrated CAD/CAM/CASE tools, system engineering application, security of software quality applications.

- In 1992, Total Quality Management started to application in managerial tasks.
- In 1994, 4000 series professional radio family, the firm changed the project management from functional to matrix management. Electronic book is added to support innovations.
- In 1995, 4100 series trunk radio family
- In 1997, 1919 mobile phone. It is the first mobile phone produced and designed in Turkey.
- In 1999, 1920 mobile phone-originally designed by R&D
- In 2000, 4400 series professional radio.

Summarizing from the above, development stages of technology innovation are as follows;

- Design innovation, (crystallized, synthesized, controlled by software, programming
- Production innovation (printed circuit)(multilevel-surface mount-application specific integrated-specific integrated
- Using facilities innovations, (tush set-screen-graphic screen-using menu)
- Support innovations (self test-test connecting with computer-electronic book
- Program management (functional centralized-matrix project management
- Engineering Innovations (CAD/CAE/CAM-CASE integrated CAD/CAE/ CASE/CAM-System Engineering-Security of quality software)

The summary of all these developments is given in a tabular format in Table 5.6.

5.11. Learning Process Model of ASELSAN

This section explains ASELSAN's learning process with particularly reference to the 'Individual firm-based latecomer-learning model' by giving details about the firm's size, competitiveness, convergence technology, its use of lean industry, sub-contracting business relations, knowledge area, international collaborations.

5.11.1. Learning in ASELSAN

This study aims to explore the relationships between learning and economic performance, how learning take place and through which ways it influences economic performance of the firm underpinning the crucial process of innovation. The starting point was the learning economy that learning is the key factor for competitiveness and enhancing capabilities.

It is assumed that individual and organizational learning are input to the 'learning organization' model according to many studies in the literature for learning process (Gu, 2000; Lundvall. 2001).

It is hypothesized that individual and organizational learning take place in ASELSAN example. Although, it is difficult to measure individual learning, the best available indicator of learning is educational background of personnel (Lundvall, 2001). Individual learning also includes the development of skills and "know-how" through initial vocational preparation. There are two indicators used to approximate firm's organizational learning: R&D expenditures and the number of patent applications in the learning organizations. Organizational learning is an indicator of investment in the development of new knowledge, new products and new processes. In the case of ASELSAN, data is unavailable because of national security concerns. Pavitt (1994) notes that R&D can be used (this is more significant in science-based sectors including electronics) as an indicator for learning process. ASELSAN has high R&D expenditures correlated with its investment.

According to definition given in the literature, there are some crucial requirements for a company or a firm to become a 'learning organization';

- It must have highly educated personnel
- It must have the ability to acquire new knowledge quickly and continuously adapt to new conditions

- It must possess the ability to work without supervision and control being able to lay down goals, observe the outcome of these goals, correct errors that may occur
- Have good interpersonal skills
- Possess the ability to solve problems by creative evaluation of different possibilities and by contributing with own ideas to reach solutions to the emerging problems (www.infed.org)

5.11.2. Learning Process Model

This study aimed to examine the ASELSAN's product life cycle from technology transfer to original design, further, producing system of system. Table 5.7 is prepared to show development of learning in the product life cycle method comparing products' life cycle with Korea- the individual latecomer-learning model.[20]

Learning Input of ASELSAN: High educated engineers, technical infrastructure, and collaborations with university, TUBITAK (The Scientific and Technical Research Council of Turkey), R&D

Learning Mechanism: ASELSAN is established for producing defense equipments and electronic systems, the main target is to produce own design equipments and systems[21].

[20] The notion of latecomer firm is introduced by Hobday (1995) (see Chapter 3).

[21] After Cyprus war, Turkish Defense Industry Foundation decided to establish a firm that would produce war and communication equipments and system for the necessity of security of nation.

Table 5.7 Learning Process Model

. LEARNING PROCESS MODEL				
	1	2	3	4
Technology acquiring period	Technological learning/transfer (OEM)	Own Design Equipment Manufacturing (ODM-OBM)	Own Designed System (ODS)	Original System (System of System)
Communication	Military Radio (license)	Professional Radio family Data terminals Data Encryption Equipment+ new generation military radio family	Tactical area communication systems	Command, control Information systems
Electronic warfare +Radar systems	Electronic war equipment modernization radar technology transfer	Own designed warfare equipment derivative radar equipment	Original electronic war +radar systems	Air defense Early Warning and command Control Systems Derivatives.1) National monitoring System, 2) Highway Automatic Toll Collection Systems
Size	(-)	(-/+)	(+)	(++)
Competitiveness	(-)	(-/+)	(+)	(++)
Convergence technology	(-/+)	(+)	(++)	(+++)
Using Lean Industry	(-/+)	(+)	(++)	(+++)
Using Sub-contractor	(-)	(-/+)	(+)	(++)
Knowledge Area	(-)	(-/+)	(+)	(++)
International collaborations	(-)	(-/+)	(+)	(++)

Source: ASELSAN magazine special issue,1999 and internal data, Author's design.

The Chronology of ASELSAN'S learning process (see Table 5.7) can be summarized as follows:
1980-(ASELSAN started production 4600 series military radio by license- After signing license contract, R&D engineers started to acquire external technology to produce original design equipment.

- 1981 –with the increase in the accumulated knowledge, produced 4200/4500 crystallized radio, integrated radio systems and additions of 4600 series with original design.
- 1982- 4200/4500-repeater radio, 4510 military hand held radio, (Own designed)
- 1983- 4821/4825 synthesized vehicle radio (Alpha) by technology transfer
- 1980-1991 (Technological learning period for military radio

ASELSAN has acquired rapid learning capabilities mainly through

- Highly educated human resource
- Technical infrastructure
- Accessing to knowledge
- Management
- Long-term target
- Knowledge management

For the South Korean 'Individual firm-based latecomer learning process model', the central argument is that firm-level learning is the chief mechanism by which foreign technology is diffused across national boundaries, between and within firm.

This study aimed to analyze ASELSAN product cycle innovations in the learning model of "Individual firm-based latecomer learning. This approach helped to explore the dynamics of firm's strategies and show how company caught up.

ASELSAN strategies will need to evolve further to confront a more complex and challenging transformation pressure of technology environment and international market and requirements for the defense of Turkey.

For developing countries, to catch-up, rather than 'keep up', with developed countries' learning and innovation is required element. Building technological capability through learning is a necessary but not sufficient condition for narrowing the technological gap with the developed countries. The technology frontier itself is a moving target and can be shifting away from the developing countries rapidly in areas such as information technology, the Internet, new materials, telecommunications, and biotechnology. Therefore, the pace and pattern of innovation in developing countries strongly influences their ability to catch-up.

Our study has identified ASELSAN in transition process, which has a different learning process with both, catching up process of firm and strategic capability management of advanced firm, there could be policy lessons for other firms to become a 'learning organization' and 'innovative firm'.

5.12. Concluding Remarks

Summing up, ASELSAN is a foremost leading firm in Turkish defense industry, and plays a role of 'system integrator', by using efficiently the relationships between sub-contractor; lean industry and university collaboration in producing discrete technologies. Taking into consideration the present situation of, and the future expectations about the firm, it seems that the "Network-Based latecomer Learning" model, which focuses on horizontal network systems, might be referred in explaining the next learning step of the firm. In other words, since ASELSAN has shifted from manufacturing industry to discrete technologies, 'Individual firm-based latecomer learning model', which pays particular attention to product life cycle, might not be sufficient in dealing with the further steps of the firm's learning process.

CHAPTER 6

CONCLUSION

The basic aim of this thesis is to explore the relationships between learning and innovations. However, this study also seeks to provide an account of learning process model. It is concerned to discover how organizational structure changes, how learning takes place and in which ways it influences the economic performance during the technological transformation.

In the Learning Economy, the information and communication technologies have been the main drivers of improving the economic performance of firms and countries.

It is clear that innovation has a crucial importance for firms on gaining and maintaining competitive advantage, for sustainable growth of governments and for nations on high living standards and prosperity. In this framework, innovative firms or learning organizations are the engines of innovation. However, it is necessary to enhance innovative capabilities and skills for possessing and maintaining the competitive advantage in the global market dominated by an increasing rate of technological change.

According to the literature reviewed in this study, it is clear that innovation and learning are the key drivers of progress and economic growth in the 'learning economy'. Fostering innovation should be re-examined, because of two main reasons; first, the fast-paced technological change is the source of business opportunities; second is the current global and competitive market that compels all businesses, regardless of their size or sector, to turn to technological innovation for their survival. Innovation fostering policy should be at the core of all modern industrial policy and should focus on technology transfer, funding, the market, regulation, culture and education needed an active role in promoting and monitoring governments.

Additionally, the basic principle is to create a learning economy that can cope with the rapid change in developing new products and services. This forces organizations or firms to implement policies aiming at human resource development, creating new forms of organization, building innovative Networks, reorienting innovation policy toward service sector and integrating universities in the innovation process.

Policy-related human resource development emphasizes that there is a growing consensus and there is a need for radical change. The change in the education system toward promoting the capability to learn and the formations of combinations of theoretical knowledge and social skills is slow. The full positive impact of information technology on productivity can only be harvested if the organizational forms develop. New forms of organization that increase connectivity and interaction between departments are key elements in accelerating innovation. The most important drivers of learning organizations in the learning economy are the networks and inter-firm co-operation in connection with innovations. The service sector-business services, communication services and other knowledge-intensive services-increasingly tend to become key sectors in relation to the over all industrial dynamics. Rethinking regulatory systems, including quality system, promote the innovation in these sectors. Integrating research institutions into the innovation systems increases and accelerates innovations because of the fact that its national marketplace becomes a part of global market. Moreover, it is important to establish an industry having strong infrastructure for competition. The important point is to create added value from technology and foreseeing technological and scientific progress.

Summarizing for the case study, ASELSAN has succeeded in producing for the defense industry. Furthermore, it is integrated into international markets through the investment in R&D, highly educated human capital, and collaborations with university and technical infrastructure that are long-term targets for technological development of firm. ASELSAN started to produce first equipment 4600 series military radios by technology transfer and, in a short period of time, acquired external technological capabilities and increased the accumulated knowledge capabilities. Technological and economic performance of ASELSAN has reached a level above the national average. In the 21st century, the target of ASELSAN is to further improve its position amongst the leading companies in the word in all areas of activity. ASELSAN'S target will be the main contractor in critical technology and system development projects.

ASELSAN is the leading firm in Turkish defense industry, and plays a role of 'system integrator', by efficiently using the relationships between sub-contractor; lean industry and university collaboration in producing discrete technologies. Taking into consideration the present situation of, and the future expectations about the firm, it seems that the "Network-Based latecomer Learning" model, which focuses on horizontal network systems, might be referred in explaining the next learning step of the firm. In other words, since ASELSAN has shifted from manufacturing industry to discrete technologies, 'Individual firm-based latecomer learning model', which pays particular attention to product life cycle, might not suffice in dealing with the further steps of the firm's learning process.

In order to compete in the international markets, an individual firm from developing countries has weakness as compared to firms from developed countries. The requirements of surviving the economic development of and increase competitive performance of Turkey, technological capability, the rate of introduction of technological innovation and with the development of technology-based industries, the structure of export and production might need to transform into technology-intensive products. (For this purpose, with regard to sectoral structure of Turkish Industry, the leader firms should be chosen to compete in international market).

In Turkey there should be government policy providing incentives to firm to enhance innovative capabilities. In industry, firms should become ‘learning organizations’ and ‘innovative enterprises’ that should be given importance in house research and development and knowledge. This attitude makes them learning based enterprise.

Turkish firms should also stay up in the race just like their competitors in any country, and this must be provided by sound governmental policies applied by the implementing agencies. Turkey needs quick and effective actions for enhancing innovative capability. There are two fundamental requirements for industrial innovation: first, continuous training and awareness rising on innovation and a business environment having priorities for investment in innovation. Second is the need for an effective national innovation policy. The innovation policy should be strengthened by a national innovation system that transfers technologies from science base to products and services efficiently and effectively.

The national innovation policy should be understood by government and must be one of the highest priorities among the other policies of the government. National innovation policy of Turkey shall be focused on beyond providing incentives for innovation. It should provide better use of resources and should share decision-making process between the government, industry and labor. Turkish national policy should rely on long-term investments in knowledge-based infrastructure, the capacity of the entire system of private entrepreneurship, human resources, investment, and advancing limits of technical knowledge. It should force the government to look for opportunities in order to enhance the social capital of Turkish society, to create networks between firms, universities, related institutions and agencies.

The government might promote technological innovation among the industry and leverage private investment in innovation to provide competitive advantage, economic growth and improved life standards.

In the globalizing world, the countries will gain prominence/prestige and economic power in proportion to their technological capabilities. It is highly probable that Turkey, possessing a young population, is to be among the producers, not just a user, of at least some of the information systems. This can be realized if the government utilizes its policies aimed at correct utilization of this potential and does not consider foreign capital in the fields where high/advanced technology is inevitable.

Summing up, it is clear that the Defense Industry is an important factor in the development of science and technology policy. ASELSAN is a foremost leading firm in Turkish defense industry and it has developed its innovation and technological capabilities at the international level with the effect of the transformation pressure of defense industry. In globalizing learning economy, there has been a pressure on defense industry to catching up developed countries' industry level. ASELSAN have developed innovative capabilities and gained competitiveness because of the producing hi-tec generic technology in the defense industry. ASELSAN is currently the leading firm in Turkey that develops national electronics technology with its "original technology development" policy,. This policy was applied nationally in Turkey for the first time, to the software, critical electronic hardware and digital electronic technologies which constitute the sub-technologies of electronics and that operate the defense systems .ASELSAN plays a role of 'system integrator', by organizing/involving the relationships/capabilities between sub-contractor; lean industry and university for producing discrete technologies. Taking into consideration the present situation of, and the future expectations about the firm, it seems that the "Network-Based latecomer Learning" model, which focuses on horizontal network systems, might be referred as the next model for the firm. In other words, since ASELSAN has shifted from manufacturing industry to discrete technologies, ‘Individual firm-based latecomer learning model’, which pays particular attention to product life cycle, might not suffice in dealing with the future expectations/ plans of the firm. According to needs of innovative technologies and globalisation , ASELSAN has to update / modify its learning model by taking consideration of future plans .

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APPENDICES

APPENDIX A

TEN POLICY PRINCIPLES FOR CREATING LEARNING CITIES AND REGIONS

According to Lundvall (2001), ten resulting principles can be derived from case studies located below. Cities and regions seeking to improve their economic performance within a knowledge-based economy through the development of innovation-intensive activities are advised to care the points explained as follows:

Inputs to the Learning Process

- Ensure that high-quality and well-resourced educational provision is in place, on which effective individual learning throughout the people's lives can be developed.
- Coordinate carefully the supply of skilled and knowledgeable individuals through education and training and the demand for them within the regional economy, so that the full benefits of individual learning may be reaped through its effects on organizational learning.
- Establish appropriate framework conditions for the improvement of organizational learning, both within firms and between firms and other organizations in networks of interaction, and demonstrate to firms.
- Facilitate effective organizational learning, not simply for a pre-selected set of conventionally defined 'high-sector' sectors, but across all those industries and services within the regional economy that have the potential to develop high levels of innovative capacity.
- Identify very carefully the extent to which the resources currently available to the region (existing industries, educational provision, research facilities, positive social capital and so forth) constitute an impediment to economic

development ("lock-in") or may usefully contribute in developing innovative strategies for the future.

- Respond positively to emergent economic and social conditions, especially where this involves the "unlearning" of inappropriate practices and bodies of knowledge (including policy makers' own) left over from the regional institutions of previous areas.

Mechanisms of the Learning Process

- Pay close attention to mechanisms for coordinating policies across what have generally been separate departmental responsibilities (for industrial Development, R&D, science and technology, education and training and so forth) and between different levels of governance (regional, national and supra-national).
- Develop strategies to foster appropriate forms of social capital as a key mechanism in promoting more effective organizational learning and innovation.
- Evaluate continuously the relationship between participation in individual learning, innovation and wider labor market changes, especially with respect to the social exclusion of groups within the regional population.
- Ensure that the regional strategy for learning and innovation is accorded legitimacy by the population of the region to be transformed.(Lundvall, 2001)

APPENDIX B

A JIGSAW PUZZLE MODEL

The jigsaw puzzle model incorporates the following steps:

1st Step. Corporate technological activities include the combination of internally accumulated technologies, externally acquired technologies and external dependent technologies.

2nd Step. The way that technological innovation activities are conducted, as performing jigsaw model, is a very complex, flexible and dynamic process where in innumerable explorations and trials and errors are made.

3rd Step. It is important to secure the individual element and also it is not less important to integrate all these elements and bring them to a successful production. All, these integration abilities include both technical and non-technical elements such as the abilities to mobilize resources.

4th Step. The composition ratio of these three elements changes from initial products to next generation products and this means that technological capabilities change and improve cumulatively.

In the view of those steps, the model seeks to answer the following questions.

1. How are the relative weight and the role of three elements comprising the dynamics of jigsaw puzzle model are changed in the Korean DRAM industry development?

2. If the composition ratio is changed, what makes the qualitative leapfrogging?
3. What are the contents of the integration abilities to combine these three elements and what role do they play?

To give explanations to these tasks, this research conducts the study on Samsung Electronics.

Design→Fabrication→Assembly→Testing

Figure A4.1. Product Life Cycle of a Semiconductor (Dae-Hee Lee (2002)

The first important step is circuit design toward making a semiconductor. CAD (Computer Aided Design) is used while designing the process, electronic circuit and circuit patterns to be drawn on the wafer and formed. This design process is the most skill-intensive costly phase in the semi-conductor production. (Yoffie, 1993).

The next step is the wafer fabrication stage which begins with the production of wafer: The wafer production process starts from growing silicon into single crystal ingots and cuts and grinds them into thin wafers.

The further step imprints circuit patterns formed in the design process onto the silicon wafer and fabricates the microstructure of semi-conductor device, thus competing the wafer fabrication process.

In order to transfer the circuit pattern into semiconductor device in the actual wafer fabrication stage, it requires very complicated process involving oxidation, etching and ion implantation.

In the assembly stage, it cuts wafers and separates chips, attaches individual chips onto the lead frame, and finally undergoes a packaging process designed to protect the chip circuit from outside, thus completing the manufacturing of semi conductor.

Last step is the testing stage aiming to ensure the reliability. This stage conducts the final test on the functions of a finished chip through computer and successful product.

A string of these semiconductor processes require many materials and equipment. These core materials used in manufacturing semiconductor include silicon wafer, photo mask, photo resist, and lead frame and package material, among other things, so it requires diverse sophisticated equipment such as wafer culter, clean room-related units and semiconductor tester.

Starting point of jigsaw puzzle model designed to analyze the technological development of Samsung electronics.

It can be concluded from the case Samsung Electronics that; this research analyzed the case of Samsung Electronics DRAM technological innovation from the viewpoint of dynamic jigsaw puzzle model. As a result, it could confirm the usefulness of this model as an alternative for existing stage model designed to analyze the development of Korean semiconductor Industry. Based on the result of this analysis, summing up the Samsung Electronics' technological innovations; the following characteristics could be pointed.

"-From the aspect of innovation strategies, Samsung Electronics could jump to the world frontier in the field of DRAM in a short period as if focused on all three elements including internally accumulated technologies, external acquired technologies and externally dependent technologies and made efforts to actively secure and efficiently use them. Furthermore, Samsung exercised the integration abilities to efficiently combine these elements, speed up the formation of core technologies, and thus led successfully innovation.

Second, from the aspect of innovative system Samsung Electronics sought to compete directly with pioneering advanced companies from the initial stage, and also put management and initiatives over the enter technology development activities under its control and strove to secure competitiveness in timing, aimed at compressing product development. In particular, since the securing of mass-production system earlier in the DRAM industry is the key to the success of the business, Samsung Electronics made tremendous efforts to earlier develop products and technologies under a strict time schedule management and these efforts provided the basis to catch-up with advanced countries."(Dae-Hee Lee, 2002).

Third, from the aspect of innovation method, Samsung implemented outsourcing method aimed at efficiently pursuing technological innovation activities. In particular, Samsung as a latecomer, in order to catch-up with leading companies, mobilized the best manpower, equipments and resources at home and overseas. This outsourcing innovation system played a crucial role in enabling.

However to use this proposed model widely for various tasks need to be done additionally, of these, research needed to determine details of internally accumulated technologies, externally acquired technologies and externally dependent technologies according to respective model stages.

Also in-depth research needs to be conduct to analyze the integration abilities to these elements and finally link them to successful production.

APPENDIX C

HISTORY AND EVENTS IN ASELSAN OVER YEARS

- ASELSAN was established in 1975, to meet the communications electronics requirements of the Turkish Armed Forces.
- Mr. Dr. M. Hâcim KAMOY has appointed as general manager on January 1976.
- ASELSAN completed its primary investment at Macunköy facilities in 1979 and within a year, the first production activities were initiated.
- In 1980, military man pack and tank radio production had started and the first delivery had been realized.
- ASELSAN designed its first hand-held radios and bank alarm systems in 1981.
- 1983, was the year for the first export business. By the end of 1983, ASELSAN had 1,434 personnel including 186 engineers.
- ASELSAN enlarged its product spectrum between 1982-1985. TBX exchange systems, field telephones, computer controlled central systems and laser range finders were among the new products.
- ASELSAN contributed to the defense power of the Turkish Armed Forces by its Electronic Warfare and Data Terminals in 1986.
- In 1987, ASELSAN participated in NATO Joint Production Project of Stinger missiles and started the necessary investment for the production of thick film hybrid circuits.
- In 1988, ASELSAN produced the first avionic equipment: Inertial Navigation Systems for F-16 aircrafts. ASELSAN quality system was certified in accordance with AQAP-4 standards. Electronic Proximity Fuse contract signed with MOD in this year.

- In 1989, ASELSAN realized the first technology transfer program to Pakistan. Combat area tactical radios production started in NRTC facilities in Pakistan under ASELSAN's license.
- In 1990, ASELSAN became 47th of the European Defense Electronics Companies. Field Artillery Battery Fire Control System and TV Transmitter production started. ASELSAN had 2,000 personnel including 330 engineers.
- In 1991, ASELSAN was organized under 3 divisions as Communications Division, Microwave and System Technologies Division and Microelectronics, Guidance and Electro-Optics Division regarding the projects within the field activity. International Defense Magazine chose ASELSAN as the 127th of the world defense companies. ASELSAN, by its treatment facilities, won the prize of the best company, which cares for its environment.
- The most important characteristic of 1992 was the addition of the Radar Systems to ASELSAN's product spectrum. TQM implementations have accelerated since 1992.
- In 1993, ASELSAN made a big achievement by establishing the Electro-Optics Technology Center at Akyurt Facilities. ASELSAN quality system was certified in accordance with ISO 9001 standards.
- In 1994, ASELSAN quality system was revised as AQAP-1 standards. Have Quick Radio production started.
- In 1995, ASELSAN engineers completed design activities of ASELSAN's first consumer product, the Mobile Phone. ASELSAN increased its exports to 19 countries. The Railway Transport System project in Power Electronics area started.
- In 1996, ASELSAN quality system was revised as AQAP-110 standards. TASMUS contract, which will provide a communication system with recent technology to Turkish Armed Forces, was signed.

- In 1997, with its Mobile Phone-1919, which is, completely designed by ASELSAN's engineers; Turkey has taken its position among the first nine countries that designed its own mobile phone.
- In 1998, ASELSAN manufactured and delivered various new equipments. Thermal camera systems, thermal weapon sights, thermal imaging equipment and laser designators were produced for the needs of the Turkish Armed Forces. Design of Automatic Toll Collection System was completed and production was started. A contract for National Monitoring System was signed with the General Directorate of Radio Communications. In addition, ASELSAN has received the "Approved Producer" certificate from the American Government for the production of LN-93 Inertial Navigation Systems.
- 1999, was a year in which various equipment designed by ASELSAN has gained considerable success. During the live fire tests of our Pedestal Mounted Stinger System, 100% success was achieved. On the other hand, design of new mobile phone was completed and Europe Approval was taken. In addition, ASELSAN has received new projects from Turkish MOD. Contracts have signed for the production of Air Defense Early Warning Command Control Systems, for the design and production of Electronic Warfare Systems and X-Band Satellite Communication Systems.
- Mr. Dr. M. Hâcim KAMOY who was the General Manager for 25 years, retired as for November 2000 and Mr. Necip Kemal BERKMAN has appointed as General Manager.[22]

[22] Summarized from www.aselsan.com.tr.

APPENDIX D

ASELSAN PRODUCTS

1980
❖ 7300 Target Firing Control Device
❖ 8020 Banking Alarm System
➢ 4600 series Vehicle, trunk Radio Families
1981
❖ 4200/4500 Series Crystallized Radio Families -Hand Radio -Vehicle Radio -Combat Area Radio
❖ Mobile Integrated Radio Systems
❖ Equipments additions to 4600 radio family -Charging equipment -Remote Control Equipment -Battery Block -Test Unit
1982
❖ 2001 Telephone deciphering device
❖ 4200/4500 Repeater Radio
❖ 4600 family Radio- Additional equipments -Tank exterior talking units -Power Supplies -Helmet Set
❖ 4510 Military Hand Radio
❖ 1200 Electronic Education Set
1983
❖ 2501 Modulator Device
❖ 8300 Computer-controlled siren system
➢ 4821 Synthesized vehicle radio
❖ 2400 Digital audio Security Device
❖ 4831/4835 synthesized combat radio
1986
❖ 8100 vehicle siren system

❖ 6200 Desert Telephone
➢ 6500 TBX Electronic central
1987
❖ 4841/4845 Synthesized repeater Radios
➢ 7800 Laser Distance Measuring Device
1988
❖ 7400 Battery Firing Management Computer system
❖ 8200 Computer-controlled irrigation system
❖ DT-7221 SEMAC Speed Secure Message Transmission system
❖ 4700 UHF Hand Radio
➢ 9200 Inertial Navigation system
1989
❖ 4811/4815 Synthesized Hand Radios
❖ MILKAR-1/2 Radar EDT/EKT Systems
➢ 7500 Stinger Electronic Guidance System
❑ 7600 APGM
1990
❖ 8400 Highways Emergency Communications system
❖ 8010/8050 Bank alarm system
❖ MILKAR-3A Communications EDT/EKT System
➢ 7250 Electronic ih.t.
1991
❖ 5600 Preset Channel Radios
❖ DT-7222 Data Terminals
❖ 4900 Trunk Radio Systems -Hand held Radio -Vehicle Radio -Repeater Radio -Fixed Center Radio
➢ 1800 TV Transmitter Equipment
1992
8100 vehicle siren system
6200 desert telephone
6500 TBX Electronic switch
1993
❖ DT-7231 Mini Data Terminal
1994
❖ 9600 Frequency Hopping Radio Families -Back-pack radio -Vehicle radio -Career radio -Trunk Radios
❖ 4000 Series Radio Family -Hand Radio

-Vehicle Radio -Fixed Central Radio
1995
❖ 7810 Laser target pointer
❖ DT-7222-1 Data Terminals
❖ 4100 series Radio Families -Hand Radios -Vehicle Radio -Fixed Central radio
❖ Taxi radio system
❖ 2020 X25 Package crypto system
❖ 2025 Network Management system
❖ 5550 HF SARP device
❖ MILKED-3A Mobile Cutting and listening system
❖ MILKAR-2U Radar EDT/EKT System
➢ 4300 Have-Quick Radio Families
1996
❖ SK-4000 Digital Crypto Radio Systems -Hand Radio -Vehicle Radio -Fixed central radio
❖ MILKED-3S Fixed Cutting and Listening System
❖ R-520 HF Receiver
❖ 2010 Data crypto equipment
❖ 2015 Key production and surveillance center
❖ 3511/3514 Locomotive AA driving systems
❖ 1815 UHF TV Transmitter
❑ 7620 ADIM Project
➢ 4340 Search and Save systems
➢ 9430 Day and Night Thermal Vision systems
1997
❖ 1919 Mobile Phone
❖ 7321 Artillery Meteorology system
❖ 7461 Multi-Barrel Firing Management and Communications System
❖ 7735 MILKAR –4 HF Hab.EDT/EKT Systems
❖ 3512 Wagon preheating system
❖ 7941 Initial speed radar
❖ 4000 Series Data Communications systems
❖ PRC-4512 Single Soldier Radio
❖ 9981 MEKA Integrated Command System
❖ KMS Thermal Targeting System
❑ 7555 SHORADS and VSHORADS Feasibility Study

❑ 7610 MMIC Connection and Packaging Technologies
1998
❖ 8135/8145 Wireless Audio Broadcasting system
❖ 6690 Internal Communications System
❖ 3513 Wagon internal heating
❖ 2016/2017 Switch Production system
❖ Artillery thermal targeting
❖ 9425 D-VII Air Combat Thermal Camera
❖ Natural Gas platform guidance system
❖ EFES Laser Target marking equipment
❖ 9411 HEKOS Target Coordinate Determination System
❖ Stinger Thermal Target
❖ 8470 Automatic Transmission system
❖ 7736 DFINT-3T Portable Cutting System
❖ Graphic-display data terminals
❖ 7550 Pedestal Mounted Stinger system
➢ 9450 Thermal Gun Binoculars
1999
❖ 7738 National monitor system
❖ 1920 Cell Phone
❖ 9911 TSK Command Control Knowledge Systems
❖ 8500 Security Systems
❖ 7653 R&D-955
➢ 9445 AAS-44 Thermal Vision System
➢ 7820 Laser Bomb Kit Guidance System
2000
❖ 9961 Telescopic vision System
❖ 9523RVT-9532 GNAT-750 Sys. Portable Remote Vision Unit
❖ Management and Control Systems
❖ 6100 TASMUS Tactical Desert Communications Systems
❖ 5100 TDMA Radio Family
❖ Advanced Laser Target Determination Equipment
❖ GRC 5211 Band III Radio-link Device
❖ BAİKS 2000
❖ 7912 ARS-2000 Observation and firing organization radar
❖ 7411 ADOP-2000
❖ GPS Buried inertial navigation devices
❖ 7712 IRCM System Helicopter Integrator
❖ 7736-3 MİLKED-3T2 Portable Cutting Systems
❖ 901 Rapier MK2B Rocket SAU and I-Pack Packets
❑ 9440 ASELFLIR-200
❑ 9710 CDU-Flight Management system
❑ 9720 MFD- Cockpit Management system

446 PMR Hand Radio (
2001
➢ 6010 Satellite Communications
❖ 7560 HERİKKS Early Warning Command Control Systems
❖ 7737 MILSIS-23U Electronic War Project
❖ 9971 KEIS Project
❖ 7739 MİLKED-3A2 Mobile cutting and listening system
❖ 6020 3rd Army Corps Communications system
❖ 6030 J.Inegration M.and knowledge System
❖ 9472 Turkish Bosphorus Guidance System
❖ 7830 Rattling Snake Code. Laser Target Marking Equipment
❖ 9460 ASIR Thermal Camera
❖ 4400 Hand Radio
❖ SAGE 2000 Digital Wideband Coverage Radio System
❖ 1813 VHF TV Transmitter
❖ ACAR Frequency Hopping light-weight backpack radio
❖ HT-7243 Hand Terminal
❖ Wholesales product sales and crediting system

Source : 1999 ASELSAN Magazine; Internal Data, 2003; Planning Directories

Legend:

❖ ASELSAN designed products

➢ Products realized by technology transfer

❑ Products realized by internationally-shared development projects

APPENDIX E

ASELSAN EXPORTS DISTRIBUTION RELATING PROJECTS

	Years												
PROJECT	83-88	89	90	91	92	93	94	95	96	97	98	99	00
TV Transmitter								■	■		■		
Mobile Phone										■	■	■	■
VHF/FM Radio family	■	■	■	■	■								
Frequency hopping VHF/UHF Radio family										■	■	■	■
VHF/FM Military Radio Family	■	■	■	■	■	■	■	■	■	■	■	■	■
Synthesized Radio Family	■	■	■	■	■	■	■	■	■	■	■	■	■
Trunk Radio Family										■	■		
Desert Telephone	■	■	■	■	■	■	■	■					
Electronic Telephone Switch	■	■	■	■	■	■	■	■	■		■	■	
Data terminals			■	■	■	■						■	■
Stinger		■	■	■	■	■	■	■	■	■	■	■	■
Laser distance measuring device	■				■			■	■				
Terrestrial Observing Radar								■					
F-16 Planes INS Device	■	■	■	■	■	■	■		■	■	■	■	■
B.thermal camera													■
Flight Management Systems													■
DNTSS Thermal Vision System										■			
ASELFLIR 200 Avionic Ther. Vis. Sys.													■
Frequency hopping tactical radio family									■	■	■	■	■
Maintenance, repair, aux. hybrid circuit	■	■	■	■	■	■	■	■	■	■	■	■	■

Source: internal data, 2003