ANALYSIS OF
TURKEY'S NATIONAL INNOVATION SYSTEM

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ABSTRACT

ANALYSIS OF TURKEY'S NATIONAL INNOVATION SYSTEM

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This thesis analyses the National Innovation System of Turkey. In order to achieve this purpose, on the one hand, 'catching-up', 'forging ahead', and 'falling behind' processes of the countries and their relationships with economic growth, long wave theories, and valid techno-economic paradigm have been studied; while on the other hand, the historical evolution of the science, technology, and innovation systems, are investigated together with foresight studies, which are considered as their guide. In conclusion, with appropriate policies and implementations, it is asserted that Turkey could achieve 'quantum jump' by acquiring a number of innovation opportunities, and thus, she could increase her national productivity and subsequently, her competitive power on the international arena.

Keywords: Long Waves, ICTs, NIS, Foresight, Turkey

ÖZ

TÜRKİYE'NİN ULUSAL YENİLİK SİSTEMİNİN İNCELENMESİ

Çetinkaya, Umut Yılmaz

Yüksek Lisans, Siyaset Bilimi ve Kamu Yönetimi
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Bu tez Türkiye'nin Ulusal Yenilik Sistemi'ni incelemektedir. Bu incelemeyi yapabilmek için; bir yandan ülkelerin 'yakalama', 'öne geçme' ve 'geri kalma' süreçlerinin ekonomik büyüme, uzun dalga teorileri ve geçerli tekno-ekonomik paradigma ile olan ilişkisine bakılmakta, diğer yandan ise bilim, teknoloji ve yenilik sistemlerinin tarihsel gelişimi ve onların yol göstericisi olarak kabul edilen öngörü çalışmalarını incelemektedir. Sonuç olarak ise, uygun politika ve uygulamalarla Türkiye'nin birçok 'yenilik' fırsatı yakalayarak 'kuantum sıçraması' yapabileceğini ve böylelikle ulusal verimliliğini dolayısıyla da uluslararası rekabet gücünü arttırabileceğini iddia etmektedir.

Anahtar Kelimeler: Uzun Dalgalar, Enformasyon ve Komünikasyon Teknolojileri, Ulusal Yenilik Sistemi, Öngörü, Türkiye

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AOL	:	American Online
AT&T	:	American Telephone and Telegraph Company
BİLTEN	:	Information Technologies and Electronics Research Institute
CAD	:	Computer Aided Design
CIM	:	Computer Integrated Manufacturing
DIE	:	State Institute of Statistics
EC	:	European Commission
EDVAC	:	Electronic Discrete Variable Automatic Computer
ENIAC	:	Electronic Numerical Integrator and Calculator
EU	:	European Union
FMS	:	Flexible Manufacturing System
FL	:	Foreign Licence
FDI	:	Foreign Direct Investment
GDP	:	Gross Domestic Product
GNP/GSMH	:	Gross National Product
IBM	:	International Business Machines
IC	:	Integrated Circuits
ICTs	:	Information and Communication Technologies
IMF	:	International Monetary Found
IPRs	:	Intellectual Property Rights
ISPs	:	Internet Service Providers
IT	:	Information Technology
KIT	:	Public Economic Enterprise
KOSGEB	:	Small and Medium-Sized Industries Support Organisation

LANs	:	Local Area Networks
MAM	:	Marmara Research Centre
METU	:	Middle East Technical University
METUTECH	:	METU-Technopolis
NGOs	:	Non-governmental Organisations
NIS	:	National Innovation System
OECD	:	Organisation for Economic Co-operation and Development
OPEC	:	Organisation of the Petroleum Exporting Countries
OSRD	:	Office of Scientific Research and Development
R&D	:	Research and Development
RCA	:	Radio Corporation of America
S&T	:	Science and Technology
SAGM	:	Defence Industries Research and Development Institute
SCST/BTYK	:	Supreme Council for Science and Technology
SMEs	:	Small and Medium-Sized Enterprises
SPO/DPT	:	State Planning Organisation
STI	:	Science, Technology, and Innovation
TDZ	:	Technology Development Zone
TIDEB	:	Technology Forecasting and Assessment Directorate
TPI	:	Turkish Patent Institute
TTGV	:	Technology Development Foundation
TÜBA	:	Turkish Academy of Sciences
TÜBİTAK	:	Scientific and Technical Research Council of Turkey
TÜBİTAK-UME	:	National Metrology Institute
TUENA	:	The Main Plan for National Innovation Infrastructure in Turkey
ULAKNET	:	The Turkish Academic Backbone
UME	:	Metrology Institute
UNICVAC	:	Universal Automatic Computer
US/USA	:	United States of America

USAMP	:	University-Industry Joint Research Centres Program
UK	:	United Kingdom
USSR	:	Union of Soviet Socialist Republics
WB	:	World Bank
VCC	:	Venture Capital Companies
WW I	:	World War I
WW II	:	World War II
YOK	:	Higher Education Council

CHAPTER I

1. INTRODUCTION

Despite the considerable efforts put forth by a number countries and international organisations since World War II, the of the progress of Third World countries regarding progress for catching up with the developed countries has been discouragingly slow. The enormous gap between rich and poor countries, in other words, between North and South, keeps being one of the most difficult fundamental problems faced by the societies. Furthermore, with the impact of industrialized, rich OECD countries, the 'New Technology' wave is considered as a factor that deepens this problem by a number of circles, pointing out that this 'New Technology' would make it more difficult for the poor countries to cope with the giant problems like debts, product cost, capital accumulation, poverty, and underdevelopment. It should be admitted the fact that technical change can sometimes deepen the problem of unequal development indeed; however, this thesis asserts that it is possible for underdeveloped/developing countries, and accordingly, for Turkey in particular, to obtain some certain comparative advantages with respect to developed countries and thus, to achieve 'quantum jump' via appropriate policies and implementations.

There are few disputes, if any, vis-à-vis the vital importance of technical change in the course of economic development and commercial competition. In fact, it is widely accepted by economists from different approaches, be it Schumpeterian, Keynesian, Neo-classic, or Marxist, that there is a strong dependency between the increase in productivity on the new products produced by new and developed production techniques, as well as efficient spread of these techniques to the entire economic system. On the other hand, neo-classical and evolutionary theories have been rather effective/determining factors in the formation of the technology and innovation policies in both developed countries and international institutions like OECD. In chapter 2, neo-classical and evolutionary theories, which have been essential to the development of science, technology, and innovation policies, will be analysed in detail and then the basic arguments and assumptions of both these theories, as well as several policy tools and their implementations will be examined, using these theories.

Notwithstanding all these theories and explanations, the ongoing pessimism does not arise from the disbelief to the potential of scientific and technological development in solving the problems like poverty, health problems, etc. However, it rather rests on practical problems, which the Third World countries encounter in the realisation of investment and development programs. These problems originate from the oppressive competition created by the more complicated and newer technologies of developed countries, which, in turn, are supported by their scientific and technological accumulation. In fact, the situation displays paradoxical characteristics, as previously accumulated capital is required to produce new capital, as well as previously accumulated knowledge is required to absorb new knowledge, skills must be available to acquire the new skills, and a certain level of development is required to create the agglomeration economies that make development possible. In other words, the logic of the system dynamics is the rich get richer, but the gap remains and broadens for those left behind.

Regardless of this situation, there are such interesting examples that should be revised within the whole picture. In 1960s, South Korea was rather weak in industrial terms suffering post-war poverty. Interestingly enough, it is the same country, Korea, not any OECD country, which developed to a level to export 256 KB chips after Japan and US. Obviously, this does not mean that Korea has solved all its political, economical, social, and technological problems; even after several years, South Korea still has a long way ahead to develop a strong competitive background for leading industries in terms of product renewal capacity. However, it is still an important point for Korea to become a leading country in electronics within a time frame of 30 years. This process of 'catching up' in Abromovitz's terms should be considered in a wide historical perspective in order to be understood better.

The first economist who studied the problems of developing countries was Friedrich List, whose book on The National System of Political Economy might just as well have been called 'The National System of Innovation'. The main concern List had was the problem of Germany's overtaking of Britain, and for developing countries, he advocated not only the protection of infant industries, but also the design of a broad range of policies to accelerate or make possible, industrialisation and economic growth. Most of these policies were related to learning about new technology and their application. He clearly anticipated many contemporary theories on 'national system of innovation'. Not only did List anticipate these essential features of current work on national systems of innovation, he also recognised the interdependence of the foreign technology import and domestic technical development. Countries should not only acquire the of other more advanced countries, but they should also accomplish by their own efforts.

As stated by List in the process of catching up with Britain, US trusted not only in customs rates, which is surely an important tool, but also in technology. Development of education system and design capability in terms of product and production management had also an important role in the competition of technological leadership, together with the increasing importance of professional R&D. In other words, organisational innovations became determining in catching up with and overtaking a country holding the leadership, contrary to only suffering a theoretical rigidity and inertia. Naturally, US was not the only one experiencing this catching up period; Japan has also set a great example in catching up with both Europe and US. However, on the other hand, all these 'catching-up' stories bring to mind the question: can this success be achieved by developing countries as well?

Some changes in technological systems create such long-term results that they have a great impact on overall economic system. These changes are 'creative gales of destruction', constituting the main axis of Schumpeter's (1939) 'long cycles' in economic development theory. Spread of steam and electric power is such changes with deep impact, just like today's technological innovations in ICTs field. 'Techno-economic Paradigm' concept, by definition, includes the process of making an economic choice among technically possible innovations. In fact, it takes relatively long time (a few decades) for a paradigm to become evident, and much longer for it to spread over the whole system. This is a complicated interaction process between technological, economical, and political powers, in which institutional innovations gain importance. There are a number of economists theorising this process; such as Dosi –change of technology paradigm-, Nelson and Winter –generalised natural trajectories-, Sahal –generic technologies and avenues of innovation-etc.

Among others, Carlota Perez's approach will be preferred and followed in this study. Perez asserts that the development of a new 'techno-economic paradigm' brings new rules and habits meaning 'the best practice' to the designers, engineers, entrepreneurs and managers; and these new rules and habits are different than the previously dominant paradigms in many aspects. Such technological revolutions cause rapidly changing production functions for both old and new products. General economic and technical benefits gained through the application of new technology to the product and production management designs, reveal themselves gradually and new 'rules of thumb' settle in accordingly. Such changes in paradigms make the 'quantum leap' possible in potential productivity. However, at the beginning, this jump takes place only in a few leading sectors. It is not likely to happen in other sectors without the long-term organisational and social changes. Perez, as an explanation of Kondratieff's 'long cycles' thesis, made a more convincing explanation of 'long waves' thesis, elaborating the term that was first stated by Schumpeter (1939). According to Perez, chips have been the basis for the fifth cycle; similarly, oil-gas-synthetic materials have been the basis for the fourth Kondratieff; as to the third Kondratieff, the paradigmatic bases would correspond to steel-copper-metal alloys and for the second iron-coal; and finally, the key factor of the first Kondratieff corresponds to iron-raw cotton-coal. Today in most leading industrial countries, new ICTs paradigm, having its foundations in electronics, telecommunication, and computer industry, which is among the most rapidly growing industries, has caused a huge increase in technical performance, a decrease in the costs and an anti-inflationist course in the prices. This technology not only affects the other sectors, but also changes the stones in the whole system from the production to the management.

Catching up periods in Third World countries should be evaluated in such a paradigm shift context; bearing in mind the example that the previous leaders of oil-intensive production technologies, such as US, have developed a more rigid institutional structure than newly industrialised countries, such as Japan. In these circumstances, besides the importance of the forthcoming quality of international regime, any following country –such as Turkey- should invest on science and technology infrastructure, and obtain an institutional innovation capacity. Obviously, Turkey will confront very severe obstacles on the road to industrialisation. At this present point, there will be a number of difficulties, such as international loans, etc., until achieving the capability of innovating production techniques and products using her own technology. On the other hand, as discussed above and will be discussed in Chapter 3, Turkey's following the path of Japan or US, does not contradict with the thesis or the arguments in it, but rather supports to an extent.

However, it is obvious that reaching these points depends on sustainable economic development, increasing the competitive power by the reinforcement of technological capability, increasing the productivity by technological innovations, development of technology intensive industries, and change in the imports structure towards technology intensive products. In other words, if GNP per capita is aimed to catch up with EU average by an increase in competitive power, with a perspective to realise EU membership, Turkey needs to take a number of vital steps, which include: a clear development strategy; an extensive industry, technology and innovation policies; an effectively working national system of innovation; and a long-term foresight study which will show the way to application strategies.

In the Chapter 4, historical development of science technology and innovation policies, essential to the targets mentioned above, will be analysed together with the development of present dominant policies. Deriving from this analysis, science, technology and innovation policies of Turkey since 1960s and its goals, which could and could not be achieved, and their reasons will be discussed. It is aimed to take a picture of Turkish innovation policy in the light of previous experiences and at the same time to reveal the defects. In addition, Vision 2023 project, which is very important in terms of these defects and determination of a guideline for future, will be reconsidered together with its processes, and the outcome of this project -SWOT analysis of Turkey- will be evaluated.

This thesis extends its argument in Chapter 4 stating that it is not necessary to have all new technological innovations and production capabilities of this new techno-economic paradigm for Turkey to catch up with it. What should be done is to create imperative essential conditions to be able to produce a certain part of products and services of the new technology depending on its own conditions, resources, and comparative advantage. To create these conditions, achieving a paradigm shift period is presented to be a more appropriate option in the thesis. What is fundamental in this argument is that the existence of a certain industrial sector is not the most crucial aspect in acquiring competitive power, but rather, it is technological capability that is determinant, as List also suggests; in other words, it is the National Innovation System as a whole, not a series of individual products. Hence, as the conclusion this argument is maintained with the particular example of Turkey, brainstorming on what Turkey should do concerning her own National System of Innovation in order to accomplish 'quantum jump', relying on the arguments laid in the thesis[*].

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[*] The figures and tables that have not been referenced in the thesis belong to the author himself.

CHAPTER II

2. THEORETICAL FRAMEWORK

Although neo-classical theory has been the prevalent approach in economy for a considerable period of time, the incapability of this theory in explaining the technological changes and innovations that took place particularly after 1980s, led to the preponderance of evolutionary 'Schumpeterian' Economy (Evenson and Westphal, 1994). On the other hand, these two theories have been rather effective/determining factors in the formation of the technology and innovation policies in both developed countries and international institutions, like OECD.

2.1. Neo-classical Approach and Evolutionary Approach

In this chapter, neo-classical and evolutionary theories, which have been essential to the development of science, technology, and innovation policies, will be analysed in detail. The aim is putting forward the basic arguments and assumptions of both theories as well as examining several policy tools and implementations of those as utilised by these theories.

2.1.1. Neo-classical Approach

It is assumed in this model that the most effective utilisation of resources by the society is only possible in a fully competitive market. Within this framework, it is postulated that the resources required for technological innovation can be provided by the markets in the most effective manner. This effective allocation can be realised provided the three pre-conditions: excludability, rivalry, and transparency. Excludability and rivalry denote the consumption of a commodity only by a consumer, in other words, the usage of the commodity by a consumer excludes its usage by other consumers, requiring the purchase of the commodity by themselves in order to utilise. Transparency, on the other hand, implies the condition that the consumers can have access to all the information like price, quality, etc., which would let them act rationally.

Particularly after the works of Nelson (1959) and Arrow (1962), a number of neo-classical economists suggested that innovations do not comply with the conditions stated above which might result in market failure, and thus, the state should influence the resourcing processes by means of science, technology, and innovation policies. There are four main reasons causing market failure, as analysed below.

Compared to the physical commodities, a significant difference of innovation and knowledge is their characteristics more as a public commodity, which weakens their excludability and rivalry attributes. In other words, the purchase of innovation and knowledge by a firm does not exclude the use of others; on the opposite, widespread usage of innovation and knowledge contributes to the production of new knowledge, and thus improves their own value. Additionally, while the production of innovation and knowledge generally cost much more than physical commodities, the cost required for their r*e*production is negligible, as seen in the computer software. Briefly, the prevalent public commodity aspect in innovation and knowledge, and the increasing importance of scale economies, lead to the emergence of natural monopolies or legal monopolistic structures (IPRs) in the markets. While this structure is required for the promotion of innovations, on the other hand, it hinders the most effective allocation of resources.

Another reason for market failure is the uncertainty characteristics of the innovation activities. In other words, the technological uncertainty concerning the success of innovative activities, the uncertainty in the market related to the adaptation of the innovation, the commercial uncertainties regarding achieving survival by making different/better innovation than the other producers, and the impossibility to withhold all the technology/capability/ knowledge acquired as a result of this innovation activity, leads to the high risk factor, and thus, high costs in the financing of innovation activities.

The third reason is the situation called as the *Arrow dilemma*. The setting up of prices and thus allocation of resources will provide the market mechanism operates. The prerequisite of this operation is transparency, which is to provide all and proper information about the products. On the other hand, this prerequisite cannot be fulfilled for innovation and knowledge; if transparency is provided in the market, then everybody will be able to own these and there will be no market activity. On the other hand, if transparency cannot be provided, then the potential customers will not be aware of these and a certain demand cannot be established. Under these circumstances, innovation will be shallow for the market and market mechanism will not be able to operate properly.

The last reason is concerned with the externality characteristics. The firm that undertook the innovation activity cannot withhold all utilities of its activity, and by some certain means such as the transfer of its staff to other firms, the imitation of the product, etc., it can contribute to other firms. In this case, the social benefit of the innovation activity becomes more than its private benefit, which results in the insufficient resourcing of the market mechanism for the innovation activities.

According to an OECD study (2000), while the private benefit of R&D activities is 10-20% in developed countries, the public benefit is around 30-100%. R&D in general markets, particularly in the markets where capital markets are not developed at the desired level; state intervention is needed to provide the balance between the private and social benefits of the innovation activities. Unequivocally, during the baseline researches and pre-competition activities, where the difference between the private and social benefits, and where externalities, and public commodity characteristics are more dominant, state intervention is required for the support of SMEs, which relatively have difficulties in accessing the capital markets, and for the reasons stated above.

In addition to the four reasons of the market failure mentioned, there are two more reasons in neo-classical economy that require the implementation of STI policies. The first reason is the need for STI policies in order to provide the required equipment and knowledge for the production or transfer of some public commodities and knowledge, in situations where their production/dissemination is undertaken by the state, as in the defence technologies. The second reason is the requirement for the establishment of the legal (e.g. IPRs) and institutional framework needed for the operation of the free market economy. To put it clearly, the identification of IPRs and determination of related legislation have significant impact on the direction and pace of the scientific and technological development. On the other hand, as any privilege/right of monopolisation given to the innovation-maker would destroy and eliminate the fully competitive market, this discourse of neo-classical economy is insufficient in the field of innovation; which will be discussed in more detail in Chapter 4.

Alternatively, the suggestion/criticism of neo-classical economists regarding STI policies is the need to implement policies of neutrality. It is claimed that the policies to be implemented would spoil or exploit the operation of the market mechanism (Lipsey, 1999). Therefore, recently, the term ‘government failure’ similar to market failure is expressed to utter/explain that such policies would not be market friendly due to the reasons like lobbying, and when reaches to a wider scale taking no action would be the second best solution. On the other hand, as mentioned evolutionary economists expressed that the neo-classical model is insufficient in explaining the developments after 1980 and compiled their criticisms under four headings:

According to Lipsey (1988), the neo-classical approach ignores the *transformation of the given conditions*. In other words, the basic economic problem investigated by the neo-classical economists is the allocation of resources, more directly, the neo-classical suggestion regarding STI policies, is increasing the returns from these activities by decreasing the cost of R&D activities through incentives, tax delaying, etc. or by generalising the utilisation of the benefits of these activities. However, the increase of the technological capability of a firm is overlooked in this approach. Another criticism by the evolutionary economists is related with the fully competitive market circumstances. The focal point of criticisms is that the reason for the firms to undertake innovation activities is to acquire a monopoly situation at the market at least for a certain period, and IPRs are set to assure this monopolist situation and benefits in the market. As stated by Soete and Weel (1999), the neo-classical approach considers the technological development as a *linear* process; however, technological change arises not only due to the price changes, but also due to the intense relationship among the system actors, such as universities, R&D institutions, etc. The last major criticism is related specifically to the practical implementation; as although the policy of *neutrality* and thus neo-classical economy is against the programs regarding certain technologies/sectors, it is expressed that this practically cannot be applied anywhere, even in US, which has the most developed market economy.

2.1.2. Evolutionary Approach

This approach is also known as 'Schumpeterian Approach' owing to the contribution and impact of Schumpeter's works (1911-1942). This theory started gaining widespread support in technology and innovation economics particularly after the studies of Nelson and Winter (1982). The basic argument of the theory is its consideration of technology as the engine of long-run economic development and highlighting innovation and learning in economic development process. Therefore, the production, processing, storage, and transfer of information and knowledge become of a vital significance. According to Smith (1995), the information/ knowledge base of any firm is; *differentiated* and *multi-layered*; *codified* and/or *tacit*; *path-dependent*; and *systematic*, both internally and externally.

The main concepts of neo-classical economics (equilibrium, profit maximisation) do not mean much in this approach; instead, evolutionary concepts (innovation/mutation, selection/sorting) become predominant. In other words, different from neo-classical model, evolutionary model analyses the ways in which firms develop new technologies and adapt to technological innovations. The focus of this approach is the system composing of different technologies -as both a reason and result of innovation-, capabilities, organisations, and implementations. According to Metcalfe (1995):

> [T]hat set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such, it is a system of interconnected institutions to create, store and transfer the knowledge, skills, and artefacts, which define new technologies.

More explicitly, according to this approach, scientific and technological development occurs as a result of the systems that emerge due to the interaction with the firm with other firms, customers, institutions, R&D centres, etc., and most of the time, due to their collaboration. Therefore, evolutionary approach highlights that the innovation process can only be comprehended by systems approach. The level of systems approach can alter according to the subject matter analysed. According to Carlssonn and Jacobsson (1999), there are mainly seven types of system approaches;

Input/Output Analysis; having been emphasised since 1941, this approach focuses on flow of goods and services among the different sectors in economy in a specific time given. Inputs, outputs, and system processes are clearly defined. Parts of the system and their relations are taken in a mezzo (industry) level and system is accepted as stable.

Development Block Model; brought up by infamous economist Dahmen during the 1950s, the basic assumption of this model is that the new opportunities which are resulted from innovative activities could not be turned out to be economic activities and values if there are no primary inputs such as opportunities, resources, capabilities, and product market. According to this model, each innovation activity causes a 'structural tension' and economic progress is achieved when this tension is solved. Moreover, the progress may cause a new tension and if not solved, the process may become unstable. This model is accepted as the first study in the application of Schumpeterian analysis. Apart from including 'instability notion' into the analysis, in contrast to the input/output analysis, this model focuses on role of entrepreneur, which makes it a dynamic model.

National Innovation System; the notion of National Innovation System emerged at the end of 1980s, and has been studied by various well-known economists like Freeman, Lundvall, Nelson, and Metcalfe. The NIS (National Innovation System) approach is evolutionary in essence, focusing on information and knowledge as the most important resources, and considering learning as the most important process for growth. Learning is 'interactive' and 'socially embedded', providing links among firms as well as between firms and institutions, which are critical and country-specific. On the other hand, a broad definition is provided for innovation, which is regarded as covering all processes by which firms master and implement new technologies and organisational practices. However, little is told about the need for specific government policies in this approach; the emergence of competitive and dynamic businesses is viewed as 'spontaneous' and country specific. The approach admits the importance of strong educational and training systems in areas in which the country is competitive, and that of macroeconomic stability paired with strong incentives to export, but otherwise does not try to assess particular market failures in technology development and the means that they could be overcome. As a result, this approach tends to stay at a rather descriptive institutional level, with broad pictures of the components of the innovation 'system', unrelated to specific policies and learning outcomes. This concept will be analysed in more detail in Chapter 4.

Porter's Diamond Model; this model is presented in Michael Porter's book, The Competitive Advantage of Nations, published in 1990. As seen in Figure 1, four corners of the diamonds consist of; a) factor conditions (capabilities, capital, technology), b) demand conditions (particularly those of special consumers in high positions in terms of technique knowledge); c) related industries; d) firm strategies, structure, and rivals. In this model, each economic activity is taken as an industry and a part of the industrial cluster rather than an isolated activity from system. Additionally, Porter's model focuses on industry, emphasising the competition among industrial actors, and finally, this model has an important role in the establishment of the new approach, 'industrial clusters'. The model of industrial clusters has started to be used increasingly by a number of countries, due its comprehensive approach to the close interaction among the main firms and industries, in order to analyse the knowledge flow in them. Moreover, industrial clusters that are linked to each other either horizontally or vertically, may display an impressive innovation capacity, despite the low performance of NIS (Porter, 1990).

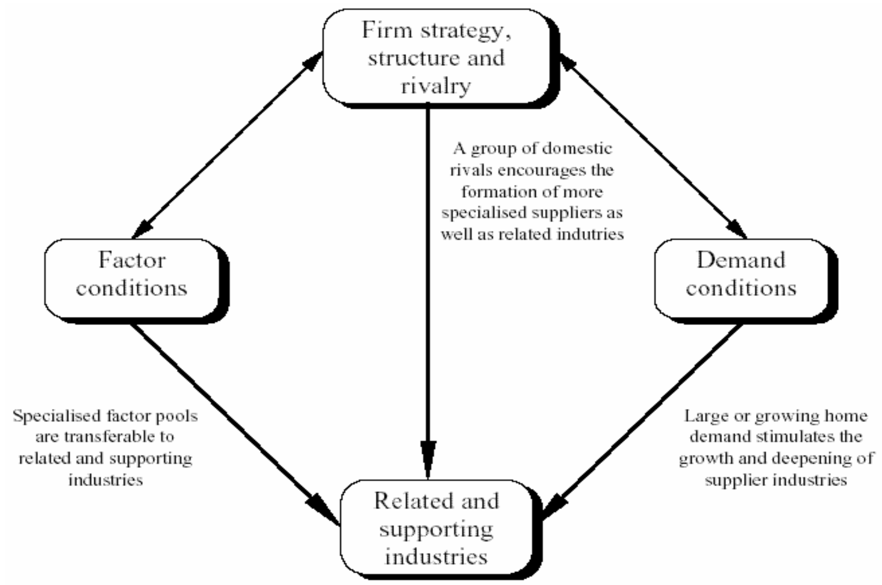

Figure 1 Diamond Model
Source Porter (1990)

Sector Innovation System; similar to Porter's model, this model also concentrates on industries and sectors, however, it suggests and focuses upon that different industries and sectors perform their works under different technological regimes (Braczyk, Cooke and Heidenreich, 1988) rather than concentrating on interaction among the industrial clusters. These technological regimes are identified with the combination of opportunity and suitability, accumulation of technological knowledge, and the knowledge infrastructure that interrelate those regimes. The dynamic character of the system is a consequence of the change in technological regimes in the course of time. Finally, technological regimes focus on competitive relations among the firms in considering the evolution of new forms of organisation as an outcome of the co-evolution of the competitive environment and the institutional environment of the firm under conditions of dynamic environment uncertainty.

Local Industry Systems; this model is proposed by Anna Lee Saxenian, after her studies in Silicon Valley and Massachusetts in 1994. This system completely concentrates on geographical character. She focused on two regions and realised that the differences between them were caused by their competition and cultural structure, hierarchy and concentration character, and their approaches to co-operation and learning. Consecutively, these differences resulted in the development of different capabilities in adapting to changing technological and economic conditions, which demonstrate the dynamic character of the system (Wiig and Wood, 1997).

Technology Systems; this approach stemmed largely from Carlsson's studies (1997). It bears some similarities with the development model; however, it has a more dynamic character. Technology systems approach basically focuses on the general application of generic technologies throughout various industries (Rothwell, 1994). According to this model, it is possible to experience different technological systems. Simultaneously, however, the types and number of actors in the system and their relationships change in the time. The boundaries of the system are not limited to the national borders. The system has three main networks; a) input-output/seller-consumer relations, b) problem solvent networks, c) informal relations. However, the definition of technological system is determined by the problem solvent networks. Thus, the system actors assist each other as well as the system in order to solve technical matters.

By considering technological development in a systematic integrity, evolutionary model undertakes a similar approach in its STI policy suggestions concerned with this systematic integrity. Different from neo-classical model, this approach is oriented towards developing the innovative capabilities of firms and national innovation system, and as stated above, the interrelationships among the system components gain significance (Metcalfe and Georghiou, 1998).

2.2. The Reasons and the Tools of State Intervention

It is implied by the innovation policies the state policies implemented in order to affect the pace and direction of the technological development process. Another important subject is the necessity of evaluating innovation policies together with other policies, as any policy directly or indirectly affect this pace and direction.

2.2.1. The Reasons for State Intervention

The national S&T policy denotes the rearrangement of resources, especially public resources, concerning the priorities determined by national S&T policies. This requires an agreement among the interest groups, which is where the role of state starts. These policies are implemented by a range of different organisations and institutions such as public and private sector R&D departments, universities, financial and monitoring institutions, technical and management services, production industries, public administrators, local administrators, etc., providing the state attain a role of orchestration.

The intended basic purpose in the implementation of national S&T policies is to position the appropriate R&D and innovation activities and to increase their level and capacity. Achievement of this aim requires institutional and legal arrangements, huge technological investments on infrastructure, and support of R&D activities. Consequently, all of these are actors in the discussion of new state role in market economy.

The ability of countries to respond rapid technological change greatly depends on the availability of the appropriate set of skills together with well-functioning product and capital markets; as these factors sustain an environment, which is conducive to innovation and receptive to new technologies. In order to achieve this aim, most countries have undertaken a broad programme of structural reform, which has improved the business climate, strengthened competition, impelled firms to improve performance, and enabled innovation and growth to thrive. In other words, the governments should respond to the characteristics of innovation process in order to efficiently and effectively take the advantages of the potentials of newer technologies in the resolution of economic growth and development problems. These governments experience improvement of innovation systems simultaneously with the problem of increasing funds and globalisation, which prevent the implementation of some national policy tools.

Also differences in financial systems, in particularly the degree to which they are able to finance risky projects, may affect innovation in emerging industries and therefore growth; as new firms have limited access to finance and may be unable to achieve growth or invest in innovation. Countries with well-developed financial markets and active venture capitalists may be better geared towards innovation and the reallocation of capital to such new industries than countries where traditional banking plays a dominant role. States have already intervened in the technology area in order to enhance technological developments and prevent market failures by taking related prevention measures.

As already mentioned before, not only market failure but also different types of systematic failures may lead to problems in the process of innovation system, as systematic failures may emerge from because of a variety of issues; disharmony among the actors of system, rigidity of specialist institutions, legislation problems, off-systems, networking, etc. Governments should resolve these systematic failures, which prevent well functioning of innovation system and flow of knowledge and technology. This is the new role assigned to the governments in the well functioning of innovation systems.

As a consequence of their new role, governments should spend a considerable amount of effort for the setting up of technology and innovation policies as a complementary part of the whole set of economic policies, and for the establishment of knowledge management systems, which encompass the entire economy of a country (Göker, 1993). The new roles of/expectations from government are categorised in the subheadings below.

Embodiment of Innovation Culture

> Overcoming the inability of many firms to cope with technical progress owing to inappropriate work organisation, poor management practices and underdeveloped techniques and incentives for incorporating new knowledge and technology require strategies on the part of firms and governments. Governments should also address the specific factors that restrain the number of technology-based start-ups and reduce their growth potential (OECD, 1999).

Firms may not always attain harmony with the changes in the world as a result of the weakness of their work organisation and management applications, and/or inability to comprehend the influence of new knowledge and technologies. Therefore, the governments acquire new tasks; the *appropriate conditions* can be created to increase research and training activities of firms; governments can design their *technology diffusion programs* in order to enhance the research and penetration capabilities of the firms into the new technology areas; governments can pay *specific* attention to firms based on new technologies; unnecessary *legal arrangements* preventing entrepreneurship can be abolished; the *regulations* arranging research and development activities can be rearranged to yield more efficient activities; venture capital activities can be encouraged.

Diffusion of New Technologies

> Governments need to look carefully at the balance between support to the 'high-technology' part of the manufacturing sector, and support aimed at fostering innovation and technology diffusion throughout the economy. They should direct their diffusion efforts across a wide range of firms, from the technologically advanced to those with lesser capabilities, from firms in traditional sectors to those in emerging industries, and to firms at different stages in their life cycle and in the services sectors (OECD, 1999).

Technical support, application, and demonstration of technology programs, benchmarking programs, and networks are important channels for the diffusion of technology and codified knowledge. Credence should be provided to these channels by government in order to supply diffusion of new technologies, not only in technology-intensive sectors, but also in other sectors, which are less accustomed to the new technologies. Moreover, public support programs, cost of which can be shared with the industry, would be helpful in improving the capability of firms to use technology in industry. Similarly, in the service sector, procurement policies can be rearranged regarding with the new service sectors.

Beyond the institutional support, development of personal networks should also be emphasised. In order to achieve this aim, interdisciplinary training programs, and the notion of life-long training/learning/education should be taken into consideration, which should particularly focus on the enhancement of team working, efficient communication, networking, etc; technology diffusion programs should consider personnel training and their circulation among the public and private sectors.

Encouragement of Networking and Clustering

> Technology and innovation policy should not focus on single firms in isolation but rather on their ability to interact with other enterprises and organisations. Governments should reduce obstacles that prevent the formation of networks and ensure that the public research infrastructure works in close collaboration with business. They can also nurture the development of innovative clusters through schemes to stimulate knowledge exchange, reduce information failures, and strengthen co-operation among firms (OECD, 1999).

The ability to establish technology alliances between firms, to engage in mergers and acquisitions, the extent of openness to trade and foreign direct investment, also play a significant role in innovation, as key developments in new areas employ a wide range of scientific and commercial knowledge and make cooperation a necessity. The interaction between networked firms and knowledge-based organisations started to become the main sources of innovation process. This situation arose from the new form of business relations, which makes it possible to establish connection through networks. At the same time, these networks represent a new interdisciplinary approach constituting the main components of technical change. Today, the strategic alliances of firms with related industries, customers, as well as their rivals are increasing owing to the requirements of large-scale R&D projects. Firms now tend to focus on maintaining the control of their tacit knowledge – their experience and skills –, and became integrated into networks that provide them with other types of knowledge. They rarely prefer to innovate alone on their own.

As the costs and risks of innovation have increased, firms became more specialised; shifting from an inward to a more outwarded orientation. Firms can no longer cover all relevant disciplines, as many key developments draw on a wide range of scientific and commercial knowledge. The need for co-operation among participants in different fields of expertise increased in order to reduce uncertainty and to share costs and knowledge.

Governments now stimulate co-operation among firms and between firms and research institutions, with an insight to promote synergy effects in order to utilise better the innovation potential of their economies. Co-operation has a number of invested benefits, including an increased scale and scope of activities, cost and risk sharing, an improved ability to deal with complexity, learning effects, and greater flexibility, efficiency and speed. In the way forward to achieve co-operation practices; the redundant barriers, which prevent collaboration and networking, should be removed; while competition rules are being assured by laws, at the same time, the collaboration for developing new technologies should not be prevented; the close collaboration between private sector and public research institutions should be ensued.

Furthermore, clusters play a significant role in the economic growth and employment. They are increasingly becoming 'centres of excellence' as a magnet with their use of new technologies, investments, and highly educated personnel. Although what kind of infrastructure help to appearance of clusters or effects of clusters on firms could not be determined exactly, clusters are usually appeared in the area where accumulation of strong scientific, technological and innovative culture is realised. In addition, although the effects of clustering on the innovation change from one location to another, the governments can support innovative clustering by way of specific regional policies and measures.

Most governments endeavour in the creation of 'centres of excellence', particularly in new fields. Besides their direct effects on development of knowledge and innovation capacities, these world-class research centres play an important role in the formation of research networks and clusters. They help to establish a collaborative environment between industry and university researchers, providing a crucial collection of specialised experts who can extend research further and diffuse the resultant technology, while acting at the same time as magnets for highly skilled people from all over the world.

Increasing R&D Activities

> In general, there is a need for new approaches to stimulating innovation that provide greater scope and incentives to private initiative and are less dependent on direct government financial support. Governments should help the science system adjust to the emerging entrepreneurial model of knowledge generation and use, while ensuring the continued pursuit of curiosity-driven research. In

> order to increase the leverage of government support programmes on private sector funding, foster co-operation among actors in innovation systems, and enhance synergy between market-driven R&D and that directed to government missions (e.g. defence, health, environment), governments should consider making greater use of public/private research partnerships and should foster commercialisation of research through patents, licences and spin-off firms. (OECD, 1999)

Obtaining sufficient benefits from public investment in science and R&D is a core task for governments. Science has an increasing importance for the countries that want to take the advantages of global stock of knowledge. A remarkable portion of these scientific discoveries and inventions come about by chance; sometimes as the by-product of more focused research efforts, but often as the result of scientific curiosity. Such discoveries, which are commonly referred to as 'serendipity', are unpredictable, by their nature. The importance of serendipity implies that governments should not exaggerate the orientation of scientific research towards certain economic or social goals. However, governments may be able to give broad directions for long-term research in areas requiring greater understanding. However, such funding should be competitive, and the prime criteria should be scientific excellence and intellectual merit.

The recession in the R&D investments may have long-term effects on the innovation capacities of some economies. Governments should try to prevent decrease in R&D. The well-known policy instruments that could be utilised in this regard are as stated in the list below:

- Tax incentives to R&D
- Policies to make capital markets more 'long-term'ist (e.g. modifications to anti-trust legislation), or turnover taxes and extensions of venture capital
- Improved skills on the labour market and further investments in trained and scientific personnel
- The encouragement of inward investment to transmit best practice
- Risk-shifting launch aid schemes
- Effective IPRs policies to enable domestic early exploitation
- Improved access to scientific expertise for potential users of knowledge (Paul S. 1999)

On the other hand, OECD suggests;

- Any type of government support to business R&D is more likely to be effective if it is integrated within a long-term framework, as this reduces uncertainty.

- The different policy instruments should be consistent, implying that the various agencies involved need to coordinate.
- If government wishes to stimulate business R&D, it should avoid providing too little or too much funding.
- Research performed in universities has potential uses for business and targeted government funding appears to increase technology transfer from universities.

Moreover, innovative processes should rely on a strong national scientific knowledge base generated by universities and public R&D laboratories and financed by public resources. It is particularly important for government-funded research to be continued to germinate the early seeds of innovation. The shortening of private-sector product and R&D cycles carries the risk of under-investment in scientific research and long-term technologies with broader applications. In addition, too much commercialisation of publicly funded research carried out in universities and public laboratories will distract the required concentration for long-term research. Where government research is required to meet public goals in the areas of health, energy and defence, etc., government policy will need to strike a balance between promotions of competition for funding versus allocation of funds for specific projects.

At the same time, scientific developments are considered as the main source of technical innovation. Industries need to use the public and university researches facilities either directly or indirectly. In fact, firms are also sourcing from the same ground with the universities as they employ their university graduate skilled personnel, who transmit the scientific approach acquired in the university to the firms. In areas where the boundaries of science and technology blurred, like biotechnology, scientific knowledge establishes the source of innovation. In all sectors, innovation processes are shaped by the relationships among science, technology and commercialisation and their feedback.

Increasing importance of scientific knowledge in many areas creates demand in production system and this demand should be supplied by national system of science. Governments should be taking the related measures: the amount of public funds should be sufficient enough to support long-term researches to be implemented by universities and public research institutions; relationships between public resource institutions and other sectors of economy should be strengthened together with the increasing the capacity of public resource institutions in order to satisfy social expectations.

In most developed countries, pre-competitive R&D activities are supported by public funds because of insufficient private sector investments in this field. For this support to be successful, some guidelines can be briefed as; the *network* among the actors of innovation system should be strengthened; *synergy* should be created between the R&D activities that are related to missions of state such as defence, health, environment, etc. and other R&D activities oriented by market conditions; *financial monitoring* mechanisms should be established and developed to increase efficiency of financial supports; different types of mechanism should be established to obtain more advantages from *public-private collaborations*.

Consecutively, rather than commercial output, government expects more economic and social outputs from the researches conducted by universities with public funds. However, examples in many developed countries, especially in the US, demonstrate that royalties from patents, license agreements and other outputs received during or after the researches are important resources of income. The researchers can establish spin-off firms by using their research outputs. Establishment of high technology firms for the commercialisation of research outputs depends on a number of arrangements on institutional flexibility, intellectual property rights, etc.

Strengthening the links between science and industry can be beneficial to both universities and other research institutions on the one hand, and firms, on the other. Universities seek industry contacts to ensure good job prospects for students, to keep curricula up to date and to obtain research support. Leading research universities seek strategic alliances with firms in order to consolidate their position in innovation networks and to establish their place in the market for knowledge. The main benefit for the firms is often improved access to well-trained human resources, although they also look for access to new scientific knowledge, networks and problem-solving capabilities.

There are several ways in which research institutions and business interact, including public/private research networks, research contracts, licensing, joint publications, flows of students from universities to industry, and so on. Some channels are of specific interest, as they pose new challenges for policy. Spin-off firms from universities and other research institutions, for instance, are a vital component of innovation networks and play an increasingly valuable role in most countries. Governments can help lower certain obstacles to spin-off formation, e.g. by improving the incentives for researchers and would-be entrepreneurs.

The mobility of scientists between science and industry is also an important channel of interaction. The lack of transferability of pensions between the public and private sectors is a major barrier to the mobility of researchers. Constraints that are more specific include public employment legislation, rules on temporary mobility and secondary employment and regulations on academic entrepreneurship.

There are other barriers that affect the link between science and industry. The interaction between science and industry takes various forms in different countries, owing to differences in institutions, regulatory frameworks, research financing, IPRs and the status and mobility of researchers. For instance, the granting of IPRs varies significantly between countries. Some countries grant ownership of publicly funded research to the performing institution, others to the inventor. Granting licences to institutions tends to make the research less exclusive. In addition, public researchers are traditionally evaluated on their research, not on their contribution to industry, which implies that they may have few incentives to work with industry in commercialising their research.

Succeed to Globalisation

> Policies are needed which capture the benefits associated with both inward and outward R&D investments and other global technological alliances, provided that opportunities and incentives for mutual gain depend on sound and predictable rules of the game. Countries should generally build on the globalisation process through openness to international flows of goods, investment, people, and ideas. They can increase their ability to absorb science and technology from around the world and make themselves attractive locations for innovation by upgrading the indigenous technology base, stimulating the growth of localised innovative clusters or competence centres, and enhancing international co-operation in R&D (OECD, 1999).

Establishment of R&D centre centres in a foreign country or technology marriages with other firms, provide remarkable advantages to firms. However, this process concerns some governments as they consider that would end up with the loosening of the country's research capability and thus, cause negative effects on national innovation capability in the long-term. Similarly, host governments are bothered due to the release of local knowledge and technologies outside, as this may increase the problem of competition in the domestic market.

Therefore, a need for policies arises which supply advantages to both internal and external R&D investments and technology marriages in a global manner. Definitely, the mutual utility that the parties would gain depends on the proper compliance with the rules of the game. On the other hand, improvement of national technology base at the international level and reinforcement of national economy networks are the pre-conditions of taking the most advantage out of research studies, regardless of location. Furthermore, encouraging the establishment of local innovative clustering centres and special centres is an important condition to attract foreign R&D investment and researchers, together with the improvement of international R&D collaborations.

Lessons Learnt from the Best Policy Practice

Although there are remarkable similarities among many OECD member countries in terms of the problems faced, each has to apply different national policies that are compliant with the characteristics of their country. Therefore, their proposed solutions should depend on the features of both the current economic and innovation system and of the unique cultural, historical, etc. aspects.

Moreover, there are significant differences among these countries in terms of traditions and capacities of the institutions associated with science and technology policies; of responsibility sharing between central and local administrations; of the roles and power of ministries; government - industry relations; and of the capacity of public - private relations. The quality of research, technology development and innovation facilities also differ from one country to another due to the market conditions. In addition, the path-dependent character of technology policies may increase the risk of inefficient government interventions, while creating unique advantages.

Members of OECD, which are accepted as developing countries, face a variety of problems. Sometimes they have to bring together inefficient organisations or they have to establish the required institutions. In addition, when the domestic firms shift from imitation to creation, their inability in reaching the required technology emerges as another major problem. Nevertheless, while trying to succeed in the process of catching-up, they can use the follower advantages by the guidance of the lessons learnt from others' experiences. One point should not be ignored that imported technology can never substitute the creation of national science and technology system, which is based on strong scientific knowledge and in this process; either through learning-by-doing or using other ways, the importance should be given to the assimilation of know-how. Furthermore, the foremost purpose of these activities can be stated as:

> [T]o achieve the highest sustainable economic growth and employment and a rising standard of living in member countries, while maintaining financial stability, and thus to contribute to the development of the world economy; to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations (OECD, 1999).

However, although a number of international organisations like OECD play an important role in the development of concepts and applications in S&T field, each country establishes its own science and technology system considering also international developments together with its own capabilities, experiences, and potentials.

2.2.2. The Tools of State Intervention

Although economic issues are supposed to be carried out by market mechanism in capitalist societies, public intervention can be seen at times in order to regulate and/or eliminate the deficiencies of system. In addition, almost all laws, regulations and other policies in a country may have an impact on the development of innovative technologies (OECD, 1998). In many industrialised/industrialising countries, government tries to enhance the national capacity for producing, transferring, and exploiting R&D, knowledge and innovative technology (OECD, 1998). Therefore, starting from the early 1990s, the changed philosophy of government intervention can be defined as such that government should aim at managing or facilitating the processes of interaction among relevant actors, and creating the conditions which facilitate R&D activities and processes of technological development (Smith, 2000). The government instruments can stimulate the supply and/or demand for innovation, which can be generic or more specific. The variety of policy instruments as seen in Table 1, which are used for the navigation of technological development into desired directions are analysed below in details.

Research Priorities – Matching Supply and Demand; Generic and Specific: By formulating research priorities, the government articulates desired research areas. This may affect the R&D agenda of universities and public research institutes, etc. or may lead to thematic R&D programmes such as improving the resource efficiency (e.g. energy) of the manufacturing industry. The aimed impact is directing R&D towards desired, strategically relevant research areas.

Table 1 Government Instruments

	Generic	Specific
Supply	• R&D support or subsidies • Venture capital • Research priorities • Initiating and stimulating networks	• R&D support or subsidies • Venture capital • Research priorities • Initiating and stimulating networks • Voluntary (R&D) agreements
Demand	• Research priorities • Initiating and stimulating networks	• Technology standards • Performance standards • Technology-forcing standards • Taxes, fees and tradable emission permits • Technology procurement • Research priorities • Initiating and stimulating networks • Voluntary (R&D) agreements

Technology-foresight exercises, Delphi studies, demand-oriented sector studies, and technology assessment are examples of instruments, which are used in the often-participatory processes of formulating R&D priorities. Experts are consulted in order to select the research areas of strategic importance for the future of industry or for the resolution of environmental problems. The generation of R&D and knowledge is related with the need for knowledge in certain areas (Kemp, 1997)

Technology Standards – Demand; Specific: By prescribing or prohibiting specific technologies, government actively seeks the elimination of undesired technologies. Technologies can be prescribed only if the performance is proven for the variety of firms confronted with regulation. A major disadvantage of this instrument is that the differences in costs of compliance by different firms are ignored. In addition, it reduces the incentive for further R&D and technological development (Kemp, 1997).

*Performance or Emission Standards – Demand; Specific; b*y formulating performance or emission standards, government formulates a set of criteria that are likely to affect the decisions of the firms to invest in the development of innovative technologies. Firms are flexible about how they can meet these standards. However, uniform standards still give rise to static inefficiency in the case of heterogeneous polluters as the cost of compliance may differ (Kemp, 1997).

Technology-Forcing Standards – Demand; Specific: Technology-forcing standards demand performance or emission levels that induce firms to invest in developing innovative technologies. It is plausible that technology-forcing standards are a better instrument for encouraging technological development than emission or performance standards. Technology-forcing standards are especially promising in the case of innovative technologies that can be commercialised at moderate costs (Kemp, 1997).

Taxes, Fees and Tradable Emission Permits – Demand; Specific; taxes, fees, and tradable emission permits are means of stimulating technology to develop in desired directions by changing the structure of financial incentives: negative externalities are taxed and/or positive externalities are rewarded. Although market-based policy instruments are generally advocated for their economic efficiency and economists argue that incentive-based instruments provide a more continuous spur to innovation than command-and-control policies, there is no consensus about the advantage of market-based instruments (Kemp, 1997).

R&D Support or Subsidies – Supply; Specific (Can Also Be Generic); by providing R&D support, government stimulates and encourages the firms to invest in developing innovative technologies. Government R&D support is one of the most common instruments for stimulating R&D and technological development, but also one of the most debated. Empirical evidence regarding the effect of R&D support is ambiguous. Some authors assert that R&D and demonstration subsidies may affect specialised research institutes and small firms like specialised suppliers. With regard to large firms, R&D subsidies will hardly affect firms' decisions (Kemp, 1997).

Venture Capital – Supply; Specific (can also be Generic): The lack of risk capital may pose a bottleneck impeding the introduction and subsequent use of an innovative technology. By raising and providing venture capital, the government tries to facilitate the final, capital-intensive stages in technological development. It is claimed that the supply of venture capital allows efficient spending of resources: when proposals are well screened, most of the loans will be paid back if the innovative technology is applied successfully. However, large sums of money are at risk for quite some time (Kemp, 1997).

Voluntary (R&D) Agreements – Matching Supply and Demand; Specific: Government may attempt to stimulate technological development by negotiating agreements with industries, according to which they commit themselves. Similarly, a commitment to R&D and technological development can be part of such agreements. Voluntary agreements are attractive to industry as they give participants freedom regarding the method and moment of compliance. The largest disadvantage of agreements is the possibility of strategic exploitation of the agreement, for instance, individual firms may show free-rider behaviour in a collective agreement (Kemp, 1997).

Technology Procurement – Demand; Specific; by guaranteeing a certain market demand, governments reduce the risks involved in bringing a technology to the market. This instrument is typically adopted to bring consumer products to the market. In the case of industrial sectors, such an approach is more difficult because industrial process technologies are less standardised and require higher investment costs than such commodity consumer products (Kemp, 1997).

Initiating and Stimulating Networks-Matching Supply and Demand; Specific or Generic; by initiating networks and co-operation between actors such as firms and research institutes, government tries to enhance the match between the supply and demand of R&D and the actual exploitation of the knowledge and innovative technologies. This instrument has been used more frequently since the early 1990s. Insisting on interaction and fine-tuning between various actors is often a design characteristic of other policy instruments. Cooperation is, for instance, often a condition for acquiring R&D support. A possible drawback is that large firms do not feel a strong urge for assistance in establishing relationships and networks with other actors such as research institutes and universities, as the necessary networks are already in place. They consider their own networks to be better developed than the ones created by governmental intervention. The value that firms place on stimulating networks depends on the nature of the technology concerned. When the technology is outside the core of the production process, government intervention in building networks tends to be perceived as more valuable (Kemp, 1997).

Conclusively, according to Glasbergen (1989), it is always possible to find examples of a policy instrument that is effective in one situation but not in another. On the other side, after the crises of 1970s and 1980s one view has gained increasing support: in this account, which proposed that the downturn in the 1970 was a turning point in Kondratieff cycle and of the long-term phenomena associated with the earlier development of capitalist societies.

On the other hand, according to neo-Schumpeterians (e.g. Christopher Freeman and Carlotta Perez), the previous model of development, i.e. 'Fordism', was broken down with the coexistence of slow growth one the one hand, and the emergence of a new industrial paradigm with enormous productive potential, on the other. According to them, there is a mismatch between new technological developments based on ICTs, and institutional and social structure. This situation requires social and institutional innovation in all countries and new directions in human social development.

From this perspective, the change can be explained shortly; the insufficiency of capital accumulation and development of productive power in explaining the economic growth and development, in addition to this pair, the legal and institutional arrangements, the effectiveness of public administration, social capital and cultural values, the sensitive of the environment and, particularly, scientific and technological developments have important effects on the economic growth. The meaning of the 'development' has changed, besides the numerical components, such as investment cost, the amount of production, and the number of workers, it also includes qualitative aspects.

Moreover, within this complex picture, a factor or a variable is self-evident: science and technology. Theoretical and applied investigations prove that the residual value which is the main focus of economic analysis, developed more rapidly with knowledge and technical innovations. Particularly, developments in ICTs and the employment of these developments for the production and design of goods and services make fundamental changes on these processes. For instance, no matter what region any information technology is launched and matured in, it becomes a world-wide technology. This concept is distinguished mostly by the radical changes in technology base of the production systems and labour process. ICT is playing a determinative role in such changes. Related to the changes in the technology base, technology content of production increases gradually. Technology is becoming a productive power replacing labour force completely and brainpower to some extent. It is also changing all the other factors of production (raw materials, production tools) together with the gradual increase in its relative importance among the factors of production. Therefore, the important role of science and technology in the economic growth and development of countries, together with today' s valid paradigm, ICTs will be discussed in the following chapter.

CHAPTER III

3. FORGING AHEAD and CATCHING UP

3.1. Long Waves

Studies on the theory of waves started to be developed in the second half of the 19th century. These studies proposed an amply diverse vision on the causes and modes of the cyclic behaviour. Different theoreticians pointed towards completely different forces as being responsible for the wave-like movements, as they have been studying the causes for instability in economy from different aspects. Those engaged in the study of cycles can be classified in two groups, depending on the nature of the work being carried out by each; *the economic staticians (empiricists)*, and *the theoreticians of economic cycles (theoreticians)*.

The economic statisticians (empiricists); they had as their function to describe the observed fluctuations and to identify new forms or new sources of data to be investigated; they collected and prepared the greatest number possible of series and described their advancements as well as drawbacks; they dealt with empirical facts. The well-known exponent is Kondratieff.

The theoreticians of the economic cycles (theoreticians); they had as their objective to identify the principles of cyclicality; they searched to establish the causal hierarchies, which related the process of the fluctuations; they dealt with the interpretation of facts. Furthermore, there are two important fundamental approaches on the nature of economic cycles:

Perpetual motion models; the cycles are unending oscillations intrinsic to a capitalist economy. They were born with capitalism and will only be eliminated when the system itself is altered. Therefore, from this standpoint, the normal behaviour of a capitalistic economy is cyclic, in other words, "…the behaviour of a capitalistic economy is cyclical" (Freeman, 1988). Cycles, therefore, do not start from 'normal behaviour', in contrast, the cycles are normality. In other words, a crisis is expected to be followed by a depression, a depression by a recovery, a recovery by prosperity and prosperity by a new crisis. Thus, the previous statements restate the idea of cyclicality, where there are moments of crises and moments of growth, which characterise macroeconomic changes. It could be stated that such periodic fluctuations design the perpetual models.

Propagation models; these theories propose that the adaptation of a capitalist economy to an exogenous change has the form of one or many waves. Each cycle is seeing as a historical individual beginning whenever a state of rest or of 'normality' is ruptured by an exogenous shock. The absorption of such a shock is marked by advancement and dephasings, which define the wave-like form of the process. The most influential version of such models is attributed to Schumpeter (1939). According to the Schumpeter theory, the exogenous disturbance is given by an innovation, which moves an economy apparently in rest or in a state of equilibrium. In other words, to quote Schumpeter himself "Any disturbance can have the power to generate oscillations…any influence over the economic process will not only produce an isolated change, but rather a wave-like movements…" (Schumpeter, 1939)

Kondratieff's Long Waves: Kondratieff wave is defined as the peak and fall of a growth mode and each crisis is defined as the transition from a growth mode to another. Each growth mode implies the establishment of a new set of social and institutional arrangements developed in such a way as to favour the unleashing of successive technological revolutions or of successive 'techno-economic paradigms'. From such an analysis, it could be said that a long wave depression means a structural crisis. Some of the main characteristics of successive long waves are summarised in table 2.

In order to understand long waves, given the depth of transformations, which affect all the spheres of society, it is necessary to amplify the area of analysis and to see the evolution of the system globally in its totality, including the technological, the social and the institutional components and their interaction with the economic sub-systems. It was Perez (1983) who first suggested that some technology systems, e.g. ICTs, were so pervasive that they dominated the behaviour of the whole economy for several decades in this way and reciprocally influenced major social and political changes.

Table 2 Tentative Sketch of Some of the Main Characteristics of Successive Long Waves (Modes of Growth)

1	2	3	4	5	6	7	8
Number	Approx. Periodisation Upswing Downswing	Description	Main ' carrier branches' and induced growth sectors infrastructure	Key factor industries offering abundant supply at descending price	Other sectors growing rapidly from small base	Limitations of previous techno-economic paradigm and ways in which new paradigm offers some solutions	Organisation of firms and forms of cooperation and competition
First	1770s & 1780s to 1830s & 1840s ' Industrial revolution' ' Hard times'	Early mechan-isation Kondratieff	Textiles Textile chemicals Textile machinery Iron-working and iron castings Water power Potteries Trunk canals Turnpike roads	Cotton Pig iron	Steam engines Machinery	Limitations of scale, process control and mechanisation in domestic ' putting out' system. Limitations of hand-opertaed tools and processes. Solutions offering prospects of greater productivity and profitability through mechanisation and factory organisation in leading industries.	Individual entrepreneurs and small firms (<100 employees) competition. Partnership structure facilitates co-operation of technical innovators and financial managers. Local capital and individual wealth.

Table 2 (cont'd)

Second	1830s & 1840s to 1880s & 1890s Victorian prosperity 'Great depression'	Steam power and railway Kondratieff	Steam engines Steamships Machine tools Iron Railway equipment Railways World shipping	Coal Transport	Steel Electricity Gas Synthetic dyestuffs Heavy engineering	Limitations of water power in terms of inflexibility of location, scale of production, reliability and range of applications, restricting further development of mechanisation and factory production to the economy as a whole. Largely overcome by steam engine and new transport system.	High noon of small-firm competition, but larger firms now employing thousands, rather than hundreds. As firms and markets grow, limited liability and joint stock company permit new pattern of investment, risk-taking and ownership.
Third	1880s & 1890s to 1930s & 1940s 'Belle époque' 'Great Depression'	Electrical and heavy engineering Kondratieff	Electrical engineering Electrical machinery Cable and wire Heavy engineering Heavy armaments Steel ships Heavy Chemicals Synthetic	Steel	Automobiles Aircraft Telecommunications Radio Aluminium Consumer durables Oil Plastics	Limitations of iron as an engineering material in terms of strength, durability, precision, etc., partly overcome by universal availability of cheap steel and of alloys. Limitations of inflexible belts, pulleys, etc., driven by one large steam engine overcome by unit and group drive for machinery, overhead cranes, power	Emergence of giant firms, cartels, trusts and mergers. Monopoly and oligopoly became typical. 'Regulation' or state ownership of 'natural' monopolies and 'public utilities'. Concentration of banking and 'finance-capital'. Emergence of specialised 'middle management in large firms.

Table 2 (cont'd)

Fourth	1930s & 1940s to 1980s & 1990s Golden age of growth and Keynesian full employment Crisis of structural adjustment	Fordist mass production Kondratieff	Automobiles Trucks Tractors Tanks Armaments for motorised warfare Aircraft Consumer durables Process plant Synthetic materials Petro-chemicals Highways Airports Airlines	Energy (especially oil)	Computers Radar NC machine tools Drugs Nuclear weapons and power Missiles Micro-electronics Software	Limitations of scale of batch production overcome by flow processes and assembly-line production techniques, full standardisation of components and materials and abundant cheap energy. New patterns of industrial location and urban development through speed and flexibility of automobile automobile and air transport. Further cheapening of mass consumption products	Oligopolistic competition. Multinational corporations based on direct foreign investment and multiplant locations. Competitive subcontracting on 'arms length' basis or vertical integration. Increasing concentration, divisionalisation and hierarchical control. 'Techno-structure' in large corporations.

Table 2 (cont'd)

Fifth*	1980s & 1990s to?	Information and communica-tion Kondratieff	Computers Electronic capital goods Software Tele-communi-cations equipment Optical fibres Robotics FMS Ceramics Data banks Information services Digital tele-communications network Satellites	Chips' (micro-electronics)	Third generation' biotechnology products and processes Space activities Fine chemicals SDI	Diseconomies of scale and inflexibility of dedicated assembly-line and process plant partly overcome by flexible manufacturing systems, ' networking' and ' economies of scale' . Limitations of energy intensity and materials intensity partly overcome by electronic control systems and components. Limitations of hierarchical departmentalisation overcome by ' systemisation' , ' networking' and integration of design, production and marketing.	Networks' of large and small firms based increasingly on computer networks and close co-operation in technology, quality control, training, investment planning and production planning (' just-in-time') etc. ' Keiretsu' and similar structures offering internal capital markets.

Table 2 (cont'd)

9	10	11	12	13	14	15	16	17
Number	Techno-logical leaders	Other industrial and newly industrial-ising countries	Some features of national regimes of regulation	Aspects of the international regulatory regime	Main features of the national system of innovation	Some features of tertiary sector development	Representative innovative entrepreneurs engineers	Political economists and philosophers
First	Britain France Belgium	German states Nether-lands	Breakdown and dissolution of feudal and medieval monopolies, guilds, tolls, privileges and restrictions on trade, industry and competition. Repression of unions. Laissez-faire established as dominant principle.	Emergence of British supremacy in trade and international finance with the defeat of Napoleon.	Encouragement of science through National Academies, Royal Society, etc. Engineer and inventor-entrepreneurs and partnerships. Local scientific and engineering societies. Part-time training and on-the-job training. Reform and strengthening of national patent systems. Transfer of technology by migration of skilled workers. British Institution of Civil Engineers.	Rapid expansion of retail and wholesale trade in new urban centres. Very small state apparatus. Merchants as source of capital	Arkwright Boulton Wedgwood Owen Bramah Maudslay	Smith Say Owen

Table 2 (cont'd)

Second	Britain France Belgium Germany USA	Italy Nether-lands Switzer-land Austria-Hungary	High noon of laissez-faire. 'Nightwatchman state' with minimal regulatory functions except protection of property and legal framework for production and trade. Acceptance of craft unions. Early social legislation and pollution control.	Pax Britannica'. British naval, financial and trade dominance. International free trade. Gold standard.	Establishment of Institution of Mechanical Engineers and development of UK Mechanics' Institutes. More rapid development of professional education and training of engineers and skilled workers elsewhere in Europe. Growing specialisation. Internationalisation of patent system. Learning by doing, using and interacting	Rapid growth of domestic service for new middle class to largest service occupation. Continued rapid growth of transport and distribution. Universal postal and communication services. Growth of financial services.	Stephenson Whitworth Brunel Armstrong Whitney Singer	Ricardo List Marx

Table 2 (cont'd)

Third	Germany USA Britain France Belgium Switzerland Nether- lands	Italy Austria- Hungary Canada Sweden Denmark Japan Russia	Nationalist and imperialist state regulation or state ownership of basic infrastructure (public utilities). Arms race. Much social legislation. Rapid growth of state bureaucracy.	Imperialism and colonisation. 'Pax Britannica' comes to an end with First World War. Destabilisation of international financial and trade system leading to world crisis and Second World War.	In-house' R and D departments established in German and US chemical and electrical engineering industries. Recruitment of university scientists and engineers and graduates of the new Technische Hochschulen and equivalent Institutes of Technology. National Standard Institutions and national laboratories. Universal elementary education. Learning by doing, using and interacting.	Peak of domestic service industry. Rapid growth of state and local bureaucracies. Department stores and chain stores. Education, tourism and entertainment expanding rapidly. Corresponding take-off of white collar employment pyramid. London as centre for major world commodity markets	Siemens Cernegie Nobel Edison Krupp Bosch	Marshall Pareto Lenin Veblen

Table 2 (cont'd)

Fourth	USA Germany Other EEC Japan Sweden Swatter-land Other EFTA Canada Australia	Other Eastern European Korea Brazil Mexico Venezuela Argentina China India Taiwan	Welfare state' and ' warfare state' . Attempted state regulation of investment, growth, and employment by Keynesian techniques. High levels of state expenditure and involvement. ' Social partnership' with unions after collapse of fascism."Roll-back" of welfare state deregulation and privatisation during crisis of adjustment	Pax Americana' US economic and military dominance. Decolonisation. Arms race and cold war with USSR. US-dominated international and financial trade regime (GATT, IMF, World Bank) Destabilisation of Bretton Woods regime in 1970s	Spread of specialised R and D departments to most industries. Large scale state involvement in military R and D through contracts and national laboratories. Increasing state involvement in civil science and technology. Rapid expansion of secondary and higher education and of industrial training. Transfer of technology through extensive licensing and know-how agreements and investment by multinational corporations. Learning by doing, using and interacting.	Sharp decline of domestic service. Self-service fast food and growth of super-markets and hypermarkets, petrol service stations. Continued growth of state bureaucracy, armed forces and social services. Rapid growth of research and professions and financial services, packaged tourism and air travel on a very large scale.	Sloan McNamara Ford Agnelli Nordhoff Matsushita	Keynes Schumpeter Kalecki

Table 2 (cont'd)

Fifth*	Japan USA Germany Sweden Other EFTA USSR and other Eastern European Taiwan Korea Canada Australia	Brazil Mexico Argentina Venezuela China India Indonesia Turkey Egypt Pakistan Nigeria Algeria Tunisia Other Latin American	Regulation' of strategic ICT infrastructure. ' Big Brother' or ' Big Sister' state. Deregulation and regulation of national financial institutions and capital markets. Possible emergence of new-style participatory decentralised welfare state based on ICT and red-green alliance.	Multi-polarity' . Regional blocs. Problems of developing appropriate international institutions capable of regulating global finance, capital, ICT and transnational companies.	Horizontal integration of R and D, design, production and process engineering and marketing. Integration of process design with multi-skill training. Computer networking and collaborative research. State support for generic technologies and university-industry collaboration. New types of proprietary regime for software and biotechnology. ' Factory as laboratory' .	Rapid growth of new information services, data banks and software industries. Integration of services and manufacturing in such industries as printing and publishing. Rapid growth of professional consultancy. New forms of craft production linked to distribution.	Kobayashi Uenohara Barron Benetton Noyce	Schumacher Aoki Bertalanaffy

* All columns dealing with the 'fifth Kondratieff' are necessarily speculative.

Source Freeman (1987)

In other words, "Long wave phenomena are a form of behaviour of the economic system…a global revolution, both technical and organisational that transforms what and the how of profitable production…. and established a new maximum efficiency and productive power" (Perez, 1989). Perez's argument can be summarised as follows:

- 'Key factors' become so cheap and universal in each long wave.
- The new products are mainly based on these key factors and other complementary inputs, which show trigger effect to the rise of new industries called 'carrier branches' and give major impetus to the growth (of) both carrier and motive branches, in other words, the entire economy.
- These new industries and services, that began to spread, inevitably bring their own organisational innovations, which mean the start of a structural transformation. When the new 'techno-economic paradigm' including new types of organisation and/or management system shows its effectiveness, its influence can be observed in older industries/services as well as in the new ones. Moreover, according to Perez, this also influences the culture and society and consequently, the governments.
- However, although the new 'techno-economic paradigm' is superior to and more efficient than the previous dominant paradigm, the acceptance of new 'techno-economic paradigm' does not take place very easy, due to its conflicted nature to the interests of the old regulatory regime and the status-quo nature of cultural norms. Moreover, turbulences or 'downswings' can also occur during this process, such as high levels of unemployment, tariff disputes, appearing of new profitable industries/companies and declining of others, political conflicts etc.
- Finally, after these turbulences, the new paradigm becomes dominant and 'upswing' or 'boom' period of the long wave starts.

One of the major characteristics of diffusion of a new 'techno-economic paradigm' is its spread from previous industries / areas to a much wider range of industries and services and to the entire economy. Moreover, the new techno-economic paradigm is not only observed in a new range of products and systems, but also in the cost structure of all possible inputs to production. In other words, inputs which are described as the 'key factor's in Perez's argument should satisfy the a number of key conditions; i.e. *falling cost*, *rapidly increasing supply*, and *wide application*.

Falling cost; means that only major and persistent changes in the input cost structure cause the transformation of decision rules and 'common sense' of producers, while *rapidly increasing supply* denotes almost unlimited availability of supply for a long period is an essential condition for taking investment decisions, and *wide application* suggests that key factor(s) should carry the potential in being directly utilised in many products and process throughout the economic system.

In this sense, the previous characterisation would support the relevant basis to state that chip manifests the fifth peak of the long wave, which are mentioned by Kondratieff and analysed by Schumpeter. Similarly, oil-gas-synthetic materials have been the basis for the fourth Kondratieff. As to the third Kondratieff, the paradigmatic basis would correspond to steel-copper-metal alloys and for the second iron-coal. Finally, the key factor of the first Kondratieff is epitomised by iron-raw cotton-coal. Therefore, any input accepted as 'key factor' (Table 2, columns 4), might already be existent or used long before the new paradigm had developed. However, the potential of newer can be recognised when the older and its related constellations of technologies give important signals of diminishing returns and approach its potential limits for further increasing productivity and profitable investments. Furthermore, the appearance of key factor should not be perceived as an isolated input, though it may crash the bottlenecks of the old technologies. After a certain period, the new core input acquires its own dynamics with a rapidly growing system of technical, social, and managerial innovations but it still operates under the old paradigm. Then, the new technology system crystallises as a new 'ideal' type and becomes the common sense of production, and its management after a long period of hesitation; as the management/decision makers gain confidence after a long period of hesitation.

As mentioned earlier, the new paradigm emerges under the dominance of old paradigm and shows its difference and advantages in a few sectors (table 2, columns 5 and 6). These sectors take full advantage of the key factor(s), which can be clearly seen in their cost structure. Additionally, the new paradigm carries a huge potential in productivity and unprecedented range of new investment opportunities. This process can be separated into four phases under the light of changes in the techno-economic paradigm: *recovery phase*, *prosperity phase*, *recession phase*, and *repressive phase.*

Recovery phase represents the socio-institutional conditions favourable to the technical-economic paradigm; *prosperity phase*, the periods of high growth in global indices, *recession phase*, denotes the decline of the old paradigm, a new pattern of inversion in the markets is evidenced, and finally *repressive phase* points at the exhaustion of the old paradigm and inertia of the socio-cultural mechanism. In figure 2, it is possible to observe how long waves operate with wave declines and births in the process of interacting.

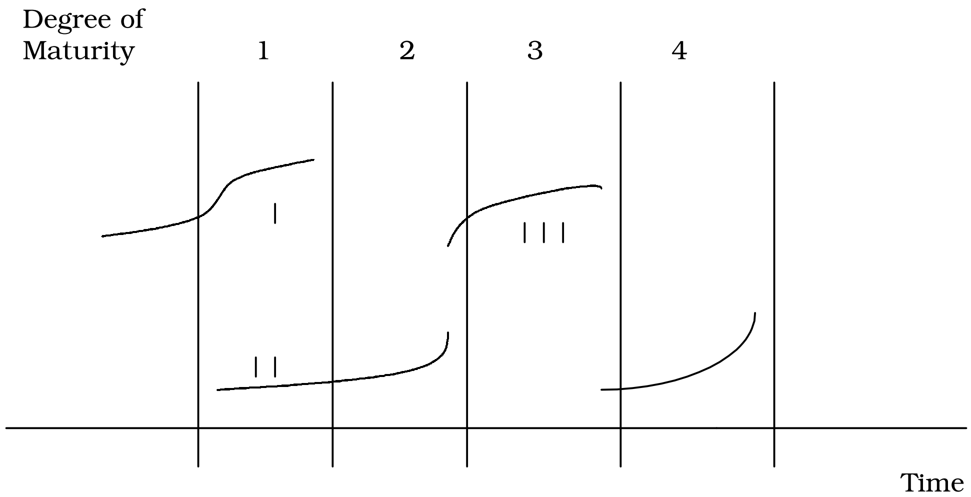

Figure 2 Long Wave Structure

Source Durgut (2003)

Thus, this radical change causes a radical shift in the engineering and management ‘common sense’ due to the reasons explained, and replaces the old paradigm. For a while, this process goes beyond the key factor(s) and technical change itself, bringing the restructuring of the entire production system. However, the unevenness of development creates a mismatch between the new paradigm and existing institutional frameworks, leading to new searches, in other words, ‘crises of adjustment’. At the end of the each wave, the structural crises of adjustment cause higher levels of structural unemployment and greater job insecurity because of the spread of the new techno-economic paradigm, which occurs before and around the lower turning point of the wave. People that lose their jobs face with an enormous pressure as their lives underwent a drastic change. People that manage to continue their jobs may need to adjust their expectations of remuneration and promotion. These adjustments may require new types of skills, capabilities, lines of hierarchy, control, etc., which pose major challenges to the previous balance of forces. To put it briefly, the new techno-economic paradigm cause and impose new types of mental and manual work, which challenge the traditional norms of production and may cause defensive struggles.

3.1.1. The Information Technology Paradigm

Widespread diffusion of new technology throughout the economic system is not a question of incremental innovation or of existing capacity in a few industries. It is a major change in all sectors of economy, skills profile, and capital stock throughout the system. The emerging new cycle is based on ICTs and its revolutionary character has been accepted promptly with fewer disputes compared to the earlier waves. Today, dominant production and organisation types both in the industry and service sector are essentially founded on 'networks' and the growth trends are increasingly led by technological revolution which is mainly based on computer software / hardware, microelectronics, internet, and mobile phones. Additionally, it is obvious that the emerging system has been affected by the scale and trends of social and political change, and by international institutions. Organisational and institutional innovations occur in the financial market -new banking products-, service sector -growing privatisation of national systems of social security in relation with reconstruction of pension insurance and mutual funds-, weakness of regulations, and the effectiveness of monetary policies at the national level, given the extreme volatility of the foreign exchange market. Therefore, the institutional and social changes, related to the technological revolution, are still unknown, which will be the focus of analysis in this part of this thesis.

Chips

Although there have also been huge cost reductions caused by the innovations in other Kondratieff Cycles like the innovations in cotton spinning and weaving, in manufacture of steel and automobiles, and in oil refining, IC and micro-electronic revolution among all components of Kondratieff Cycles, provide the most spectacular example of price reduction. The basic reason for this is that the microelectronic innovation and chips reduced the cost of storing, processing, and transmitting information.

Together with IC revolution, the roots of discovery and improvement of other electronic components such as radio, television, radar etc., can be found in the researches of European scientists in the early 20th century. Among all the rest, they owe particularly to the works of European scientists such as Hertz and Maxwell that made possible the growth of the electronic industry, and thus, are accepted as a starting point of possible growth of the electronic industry. Since then, the feature of ICTs depended mainly on the interaction between scientists-engineers, works of innovative engineers, investments of entrepreneurs, and structure of scientific institutions.

The first thermionic valve was invented by Sir John Ambrose Fleming in 1904, while Italian inventor G. Marconi, who showed the feasibility of ship-to-shore, shore-to-shore-, and ship-to-ship radio communication, set up his wireless

Telegraph Company in Britain in 1897. The importance of these types of innovations was realised by some governments considering their potential utilities in times of both peace and war.

During WW I, government-financed R&D activities have been started for naval armaments, chemical warfare, aircraft, tank etc. Two instances will help to figure out the approach of the governments of the era to the subject. In 1903, *Siemens* and *AEG* of Germany established a joint subsidiary for radio communications, which they named as *Telefunken* and government-financed R&D was invested in TRE (Telecommunication Research Establishment, now RRE), employing a huge number of scientist and engineers. The main factor, the driving motive for the establishment of a joint subsidiary for radio communications has been the competition between the naval arms of Britain and Germany. Another instance is from US, where a powerful unified national radio company (RCA; Radio Corporation of America) had been established, obtaining a strong encouragement from the US Navy. However, starting from inter war period, the electronic industry, being the first technology to enjoy such massive support, became a subject of government interest and regulation, when the development of radar, gun control systems, oscilloscopes, etc. became one of the control concerns of all combatants.

Beyond the support of governments in R&D for electronics components and circuits, it was the Bell Laboratories of AT&T, civil R&D in transistor technology, which led to the key developments in semi-conductors. According to Tilton (1971), Bell Laboratories could be regarded as a main actor in the establishment of US semi-conductor industry, while government support continued in procurement rather than in R&D itself during this process.

Like the earlier examples of automobiles, oil refineries, and steel production, combination of technical and organisational innovations in ICTs, provided a range of extra-ordinary powerful methods of cost reductions, which provided a spectacular advantage to large firms. In 1972, the development of microprocessor pioneered by Intel led to the transformation of both semi-conductor and computer industries, providing cheap and wide-scale production of chips.

Thus, starting from the 1960s, strong and interdependent relationships among the electronic industry, telecommunication industry and computer industry became an emerging constellation in ICT. Microelectronics, computer, and telecommunication industries undeniably became an enormous market, where the cooperation and competition of new firms can be observed.

On the other side, because of the more than a hundred steps of coating, baking and etching, the production of semi-conductors are still complicated and difficult processes, and as stated by Appleyard *et. al.* (1996): "The complexity of the manufacturing process also means that isolating and identifying the causes of yield failures requires considerable time and effort". Therefore, while the uncertainty and turbulence still exist in this sector as a barrier for opening new plants and new R&D, the microelectronic sector yet remains R&D intensive, which costs approximately ten per cent of total expenditure.

Computers

With the exception of Blaise Pascal's calculating machine, Charles Babbage's 'Analytic Engine' and 'Difference Engine' can be regarded as the ancestors of modern computers, although Babbage could not complete his machines due to inadequacy and lack of electronic components. Before the development of adequate electronic components to provide fast, cheap and efficient machines, there were different types of machines such as Z1, Z2, Z3, Z4 etc. However, the history of these machines can give an insight on the importance of computers' role in today's world.

Withdrawing their official support, the Nazi Germany cancelled Zuse's project on valves, who was hired by Telefunken as was a well-known engineer for his works on the development of electronic computers and Z4 machine that was used by Henschel Aircraft Company for design of aircraft wings. On the other side, American and British governments could easily recognise the importance of physics and mathematics in computer science. 'Colossus', a computer developed by Alan Turing was used by British Army Force for cracking the German 'Enigma' military codes. Another example is EDVAC and UNICVAC, which can be seen as the antecedents of computer industry in US. They were improved by Von Neumann, who developed the basic concept of the computer containing a central processor, memory devices, input-output devices, making use of sequential programming. Still, sequential programming is acknowledged as the basic paradigm for computer industry.

According to Katz and Phillips (1982), the first enthusiasm for computers rose from military and universities and then, industry entered this sector, as they had some experience with the early wartime design. However, these earlier electro-mechanical machines required frequent replacement of the valves, occupied a large space, they had a problem of overheating caused by numerous valves. In other words, the first electro-mechanical machines were more a thousand times slower than today's electronic computers.

When IBM produced the 650 model, due to the pressure resulting from the Korean War in the early 1950s, IBM forecasters believed that it would sell a maximum of 200 machines. However, more than 1,800 machines were sold out, and it was the time to wake up for IBM, which is maximed as, *"IBM slept soundly"* (Belden, 1962).

According to W. D. Hoffman (1976), although IBM was successful in the 1950s and 1960s due its catch-up strategy, it remained generally a fast follower rather than a first innovator. With the development of 1401 and 360 series, IBM became one of the most profitable firms in the world owing to the success of its large mainframe business computers. Despite the attempts made to imitate the success of IBM by a number of European firms in France, Germany, UK, and Sweden, it remained as the most successful in the area for a considerable period.

Another important development came with the Molins System in 1969, which could be considered as the first FMS that proved combination of several machine tools, together with guided vehicle and CAD technology. The concept of CAD technology had been originated by John Parson in 1948, who demonstrated that the movements and speed changes of precision milling machine could be controlled by a mathematical computer. Moreover, John Diebold, in his well-known book *Automatic Factory* (1952), emphasised that these types of applications in computers can effectively be used after a prolonged period of "training people with new skills, reorganising management systems, and redesigning process".

On the other side, until the advent of PC owing to Intel's microprocessor technology in 1970 that computer availability everywhere, large computers were operated for special purposes such as sales records, payroll calculation, etc., whereas small computers were used in manufacturing, medicine, scientific works etc. However, the role of small computers in daily life was a brand-new concept, which has been fostered by this brand-new PC concept. Additionally, it may be said that until that time, Fordist paradigm still prevailed in the organisation of large firms.

The characteristics of Fordist paradigm stimulated the acceptance of different trends such as a 'change of techno-economic paradigm' and inevitably the criticism of mass production, e.g. as also mentioned by Dertouzos in his "Made in America". The new paradigm has been supported by computers, microelectronics and telecommunication, which provide technically reliable and economically efficient growth and became chief of engine. Naturally, this was achieved when the decreases in price, developments in performance, design and increased user-friendly characteristics in the 1980s-1990s.

Today, the powerful computer systems based on parallel processing, enable a number of computers to be combined together. According to Molina (1989), the interactions between industrial R&D and university groups as well as the interaction between semi-conductor firms and computer firms are important again in developing a new architecture. Finally, the rise of network computing provided new opportunities for changes in telecommunication industry.

Telecommunication

The electric telegraph of Wheatstone (UK) and Morse (US) in 1830s and 1840s had provided a type of communication that had acquired a great importance for military, railways and for news agencies. However, Alexander Graham Bell's invention of telephone in 1875 was not at first considered as a revolution in telecommunication, as the successive system was depending on the distance and at that time, it was available only for short distances, whereas telegraph could be used over long distances.

Nevertheless, De Forest's invention of triode electronic valve for radio, effected telephone drastically because when the AT&T obtained the right to use valve (tube) as a relay in the telephone system, telephone became an important device for long distance communications. The following big step was the use of the transistor in telephone exchanges, as manual exchanges required huge numbers of operators in order to provide connections, however, it was nearly impossible to use valves in switches as they burned out easily and consumed too much power. Therefore, between 1920 and 1960s, the telephone networks depended on improvements in electro-mechanical technology. At the end, in 1960, the first electronic exchange using transistor technology was installed in US. Starting from 1960s, a convergence in industries of electronic, computer and telecommunications had been observed, which had been developing independently. Thus, the constellation of new, fast-growing industries had now fused into a new technology system, which had been called as 'ICTs'.

As stated by Von Tunzelman, Soete (1988) and Duyster (1995), this convergence did not lead to a 'business convergence'; many firms in each industry continued to pursue their own specialised business interests and strengthened their competition in their own fields respectively. Duyster concluded that due to the production, marketing strategies, know-how, and skills, there were barriers against firms to enter into the sector, however, the process ultimately leads to the repositioning of firms through strategic alliances and networks. This will be focused in the following section.

Another important problem in the development of the communication sector had been the carrying capacity of cables. This problem has been solved by the development of optical fibres in the 1970s, which provided the improvement of the magnitude and liberated the system from bandwidth constrains. At the same time, owing to the satellite communication and cellular telephone networks, the wireless communication was undergoing an equally radical transformation.

> As for descendants of television, the dominant traffic of the future will be store and forward of digital data among millions of tele-computers. These machines will be capable of summoning or sending films or files, new stories and clips, courses and catalogues anywhere in the world (Gilder, 1993).

Gilder concluded that technical change would cause institutional change, and in consequence, both centralised broadcasting stations and/or telephone systems would no longer be needed. Certainly, this assumption depends on technical changes as well as political, cultural, and social changes. However, the rapid growth of mobile phone network and their performances demonstrate that the process seems to confirm Gilder's prediction.

Moreover, today, with the privatisation of the public services is experienced in telecommunication sector, too. Having started with the Bell systems in USA, this process in telecommunications infers that a competitive environment would stimulate the growth of all kinds of new information services, as listed in Table 3. It can easily be realised in Table 3 that most of the services became available during the 1980s and 1990s, such as combination of telephony and television (cable networks), computers, and telecommunications (including internet technology).

Internet service providers became the most rapidly growing sector, having enormous effects on economy, particularly on the delivery of services of all kinds. In consequence, the cost of warehousing and delivery systems became more apparent, and consumer responses turned out to be less negative than often assumed.

Table 3 Information Services Potentially Available to Households as Envisaged in the 1970s

Passive entertainment	People--people communications	Interactive television	Still-picture interaction	Monitoring	Telephone voice answer back	Home printer	Computer terminals (including the view data television set)
Radio Many television channels	Telephone	Interactive educational programmes	Computer-assisted instruction	Fire alarms online to fire service	Stock market information	Electronic delivery of newspaper/maga zines	Income tax preparation
Pay television	Telephone answering service	Interactive television games	Shopping	Burglar alarms on-line to police	Weather reports	Customised news service	Recording tax information
Dial-up music/ sound library	Voicegram service	Quiz shows	Catalogues displays	Remote control of heating and air conditioning	Sports information	Stock market ticket	Banking
	Message sending service	Advertising and sales	Advertising and ordering	Remote control of cooker	Banking	Electronic mail	Domestic accounting
	Telemedical services	Television ratings	Consumer reports	Water, gas, and electricity meter reading	Medical diagnosis	Message delivery	Entertainment/sports reservation
	Psychiatric consultation	Public opinion polls	Environmental guide	Television audience counting	Electronic voting	Text editing; report preparation	Restaurant reservations
	Local ombudsman	Audience-response television	City information			Secretarial assistance	Travel planning and reservations
	Access to elected officials	Public reaction to political speeches and issues	Obtaining travel advise and directions			Customised advertising	Computer assisted instruction
		Television interviewers soliciating audience opinion	Tour information			Costumer guidance	Computation
		Debates and local issues	Boating/fishing information			Information retrieval	Investment comparison and analysis

Table 3 (cont'd)	Telemedical applications	Sports reports	Obtaining transportation schedules	Investment monitoring
	Bidding for merchandise on televised auctions	Weather forecasts	Obtaining travel advice/maps	Work at home
	Betting on horse races	Hobby information		Access to company files
	Gambling on other sports	literature reviews		Information retrieval
		Book library service		Library/literature/docume nt searches
		Encyclopaedia		Searching for goods to buy
		Politics		Shopping information; price lists and comparison
		Computer dating		Real estate searching
		Real estate sales		Job searching
Obtaining insurance		Games for children' s entertainment		Vocational counselling
		Gambling games (such as bingo)		Obtaining insurance
				Obtaining licences
				Medicare claims
				Medical diagnosis
				Emergency medical information
				Yellow pages
				Communications directory assistance
				Dictionary/glossary/thesa urus
				Address records
				Diary, appointments, reminders
				Message sending
				Dialogues with other homes
				Christmas card/ invitation lists

Source Guy (1985)

Changes in product and process design, and thus the availability of PCs and introduction of LANs deeply affected the old 'Fordist' hierarchical structure. During 1960s, as explained earlier, computers were used by firms and usually were typically pictured large mainframe computers in specialised data processing departments. In other words, they did not yet revolutionise the organisation of firms. The introduction of the changes mentioned in product and process design, and the increase in their availability, not only led to rapid, easy access to information but also resulted in some layers of management to become useless. Changing circumstances were reflected in the changing management styles or vice-versa; displaying certain contradictions with the Fordist style in many respects. As per Chesbrough and Teece (1996), networks became an important feature of the new organisation both within the firm and in the external relations of the firm.

An example supporting the argument stated in this text can be found in Business Week, which reads "So successful has Cisco been in selling complex, expensive equipment over the Net that busy year (1997), Cisco alone accounted for one third of all electronic commerce". Cisco managed to quadruple its output by outsourcing without building new plants. That is, the business-to-business use of Internet may turn out to be the most important source of productivity gains in the ICT revolution. Obviously, Cisco's commercial success enables it to provide technical support to its customers at a far lower cost in engineering hours. However, despite the entire positive environment caused by all of this change, this did not alter the callous business employer-employee relationship. Moreover, temporary contracts, part-time working, insecurity of employment, have become more prevalent not only in developed countries but also in developing countries.

As Castells (1998) puts, "the basic unit of economic organisation is neither a sort of entrepreneur, family, co-operation, nor a state, but the network is composed of a variety of organisations". Moreover, including Weber, a number of economists have mentioned about networks in economy and about the future of capitalist societies (Table 4). In general, it can be said that all discussions were primarily based on an intense interchange between suppliers and users of materials, components, products, and ideas. Additionally, the discussion among economists about networking does not seem to have reached at a conclusion, except one point: it is widely accepted that not only the speed of communication technologies, but also easy and rapid access to information have been opened to participants through networks.

Another aspect of networking is the growing complexity of science and technology, which had also inspired Adam Smith to underline the role of specialisation and division of labour. However, this specialisation led to a problem of 'in-house-R&D' in the organisations themselves. Because, today, networking is much more important in scientific and technical activities such as joint ventures, licensing and know-how agreements, joint data banks, etc. According to Hagedoorn (1990), this issue is much more obvious in information technology and biotechnology. As a result, it is evident that the growth of networking and the economic advantages of scale economies for firms and individuals have been accelerated and facilitated by ICTs.

Table 4 A New Techno-economic Paradigm

' Fordist'	ICT
(Old)	(New)
Energy-intensive	Information-intensive
Design and engineering in ' drawing' offices	Computer-aided designs
Sequential design and production	Concurrent engineering
Standardised	Customised
Rather stable product mix	Rapid changes in product mix
Dedicated plant and equipment	Flexible production systems
Automation	Systemisation
Single firm	Networks
Hierarchical structures	Flat horizontal structures
Departmental	Integrated
Product with service	Service with products
Centralisation	Distributed intelligence
Specialised skills	Multi-skilling
Government control and sometimes ownership	Government information, coordination and regulation
' Planning'	'Vision'

Source Adapted from Perez (1989)

Regime of Regulation

Still, the future of information society keeps its uncertainty. On the one hand, transformation of data into information and information into knowledge is still a problem for the information society -which was not resolved in -simply calling- the "knowledge society", either. On the other hand, the potential suggested by ICTs is more than remarkable; particularly regarding economy or the quality of life together with health and education.

Debates on the future of internet so far continue on what will emerge as the dominant culture, or whether it is desirable / possible to regulate internet, (e.g. prevention of pornography or racist propaganda, etc.). However, it may be suggested that in a not-too-far future, these might be determined or at least manipulated by ISPs themselves, or a decentralisation may take place by the presence of small firms that would provide a more liberal virtual environment.

This argument resulted from the debates of 1990s, when many economists, like Alberd Bressand, emphasised the role of SMEs in generating innovation and new employment opportunities. In fact, Internet has been providing millions of new opportunities for SMEs to show more presence in the economic life. However, now the emphasis shifted from SMEs to the advantages of very large global firms such as Berlusconi's European conglomerate or Murdoch's empire, which started to concentrate on combining various multimedia and entertainment interests such as newspapers, TV, football clubs, films etc. under one ownership in various countries; i.e. underwent a process of monopolisation. M. Javary and R. Marsell (2000) concluded as "the development of the British ISP market suggests a trend towards the emergence of an oligopolistic industry that is in consistent with the evolution of a network 'commons' which will be responsible to social value". Moreover, the risk that monopolistic corporate power will wield increasing political and cultural influence on the information society is quite evident. It is far away that utopian dreams of the early pioneers using the internet, who dreamt that it would provide not only a world-wide free domestic forum for the exchange of information and ideas but also a global market-place for in which the SMEs would be able to compete on global terms. Therefore, the control over the content of the Internet services will be the main issue for any domestic society, which could be reworded as 'if network could hardly ever be a partnership of equals, some partners would be more equal than others'.

The information revolution destroyed and weakened the old monopolistic power of telecommunication utilities, leading to the development of new successive services &technologies with re-regulation and renewed concentration on practices. Inevitably, the new game deeply weakened the power of national governments. The old public-owned state monopolies have been replaced by new giant global multinational and even trans-national companies. An instance to this would be Vodafone Airtouch, the Anglo-American telecommunications company, which launched a bid to merge with the German Mannesmann Cooperation early in 2000, as a move that rivalled the AOL merger in scale and scope.

While on the one hand, policies like privatisation and deregulation have been considered as a process of weakening of national governments, on the other hand, this process is a characteristic for the emergence of each new techno-economic paradigm like electrification and motorization. It can also be added that characteristics and configuration of regulation systems can be determined by the nature of technology, whereas ICTs lends itself to self-regulation networks.

To put it briefly, during the mass production periods, the role of central and local governments has been regulating and controlling the economy, which is an approach shared by Keynesians, socialists, nationalists, and militarists. Vis-à-vis this approach, it is stated that government expenditures were higher before the WW II which was usually assumed as a normal consequence due to the military or welfare purposes, whereas in developing countries, the state provided the required 'catch-up' for every field in industrialisation, economic growth, etc.

As it has been already observed, not only neo-liberal and conservative parties, but also many social democratic parties detached themselves from the idea of public ownership and central planning. In the debates of the last two decades of the 20th century, it has also been widely assumed that taxation and government expenditures should be reduced.

Besides these, the characteristics of pervasive technology influence both the government systems and corporate management systems. However, here, the term 'influence' is not used as a synonym of determinism, but indicates rather the rise of totalitarian political regimes and ideologies had caused much deeper and wider prevalence of mass production. Similarly, it can be suggested that computer networks and Internet do not necessarily give rise to 'free' competition or democratic political institution. Both the political and regulatory systems in mass production societies were quite diverse, like in the rise of German Nazism, which owed far more to mass unemployment and the complicity of some sections of big business than to the characteristics of any production system. Thus, like the ICTs revolution, any technological system can be developed and used in the fields of political conflict and ethnical arguments. However, the future of the society, emerges from the ICT revolution, would be determined by mainly strength and programs of contending social groups and political forces rather than technologies.

This argument can be followed with the current debate on taxation and the Internet. While it is a fact that the loss of revenue from certain kinds of tax, particularly corporate and income taxes reduced the power of national governments in order to attract foreign direct investment, the process itself already leads to the elimination of some taxes. Both OECD and The Economist (2000) pointed at this fact, where The Economist even suggested that it is hard to stop tax competition between governments to attract foreign investment. This argument is advanced by Charles Tiebout, in The Economist; "Tax competition will put pressure on governments to provide their services efficiently, but that need not mean they have to be minimal". This argument highlighted an important aspect of the Internet as it will make more people mobile leading to a number of ways to tax avoidance. Therefore, Internet and ICTs contribute more to the process of weakening tax power of governments.

Thus, it is proposed that there are two sides of the effect of this paradigm. On the one hand, the firms, organisations, corporations, etc. that established their network systems may become the winners in the information society even in its still premature form, on the other, it is not clear yet the position of government welfare services due to the nature of the new technologies vis-à-vis taxes. Social, economic, as well as technical innovations have a great potential and some of them might take advantage of ICTs. For example, although the internet helps tax avoidance, it also provides political mobilisation of groups all over the world. Well-known motto 'No representation without taxation' may become an important principle in the twenty-first century. Furthermore, new forms of tax may be imposed to be used for poor people and poor countries. Pollution and luxury taxes can rise. Finally, the on-line services in health and education may contribute to improvements in welfare state applications. Despite all these changes, there is still the danger of social exclusion. As stated in the Report (European Commission, 1997), universal service obligation must continue to provide for those who are not computer-numerate as well as for the rapidly increasing numbers that have no access to the internet. As a result, no one can predict the future course of events in a very unstable system, which not only effects developments in science and technology but also rate and direction of social and political change in all over the world.

3.1.2. The Information Technology Paradigm and Economic Growth

Within such a Schumpeterian framework, one may consider changing paradigms and 'normal' technological progress within existing paradigms as describing trends in discontinuous versus continuous technological development. On the other side, the critical concern about the Schumpeterian approach is that lack of macro-economic evidence of productivity gains resulting from the application and slow diffusion of new technologies e.g. ICTs. Moreover, this concern can be supported by famous Solow productivity paradox. In short, Solow emphasised that although computers could be seen everywhere, the actual measured productivity gains from their use appeared to be very small or even non-exist. In this point the previous explanations about 'techno-economic paradigm' – which express the combination of interrelated effects of product and process, technical, managerial and organisational innovations which lead to the emergence of an unusually wide range of investment and profit opportunities and a unique and new combination of decisive technical and economic advantages- help the solution of the paradox.

The latest paradigm, ICTs, can be regarded as the best example of the case, which is so pervasive and has so many features as well as one of the main problems of structural adjustment. "The whole shape of the industrial landscape is changing" (The Economist, 1986), inevitably, such pervasiveness of a cluster of new technologies brings to the question of the diffusion process across the sectors of the economy. In other words, most manufacturing and service industries, which have little previous experience with this radically new technology, face with many problems while using this new technology.

As we have already mentioned, John Diebold, in his well-known book (Automatic Factory, 1952), showed amazing foresight about these problems. Events have proved Diebold completely right. It was only in the 1980s that computerised automation in the form of FMS, CIM, and CAD stated to take off on a significant scale. This also applies to computerisation in the service sector. Moreover, according to Locket's study (1987), which dealt with information technology innovations in a large multinational company, an intense dialogue between the provider and the user was an essential condition of the successful implementation of IT innovations. In fact, in the case of information technology, the requirement of 'user friendliness' is exceptionally important and attended by special problems; the user often finds great difficulty in conceptualising and specifying his/her needs; there is a little chance for the provider to understand the problems from outside; the technology itself is continuously changing; and finally, ICTs bring together the need for reorganisation of management itself and/or of production systems, as mentioned in the introduction of ICTs. This situation almost resembles the diffusion of electric power (Table 2), after the key technical innovations made between the 1860s and 1880s. With the establishment of effective electricity generating, transmission together with social, legal, and organisational systems during 1880-1890s, the emphasis shifted towards diffusion of applications of electric power throughout the economy in both industry and households. In this phase, although technical innovations continued at a high profile and huge improvements made in the available hardware, the key problem was the organisational change in firms; change in skills, factory layout and in the attitude of engineers, managers, and workers.

Regarding the explanations in 3.1, the analogy between electrification and computerisation is convenient to illustrate the long time scales involved in any type of technical change that affects a very broad range of goods and services, where many products and processes have to be redesigned to realise the full potential of the new technology. In other words, it would be quite unreasonable to expect sudden increases in productivity in sectors far removed from the new technology. Such increases could be expected to emerge only after a fairly long process of familiarisation, of developing customised equipment, new skills and new management attitudes and structures. One may stress here the cross-sectoral aspect of the diffusion process, the 'learning by doing and by interacting' (Lundvall, 1988) and the time lags involved in moving from the potential productivity gains of a, radical new technology system to their actual realisation.

3.2. Economic Growth

> All the improvements in machinery, however, have by no means been the inventions of these that had occasion to use the machines. Many improvements have been made by the ingenuity of the makers of the machines, when to make them became the business of a peculiar trade; and some by that of those who are called philosophers or men of speculation, whose trade is not to do anything but to observe everything; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects. In the progress of society, philosophy or speculation becomes like every other employment, the principal or sole trade and occupation of to a particular class of citizens. Like every other employment too, it is subdivided into a great number of different branches, each of which affords occupation to peculiar tribe or class of philosophers; and this subdivision of employment in philosophy, as well as in every other business, improves dexterity and saves time. Each individual becomes more expert in his own peculiar branch, more work is done upon the whole, and the quantity of science is considerably increased by it (Smith, 1776).

> It is a scientifically based analysis, together with the application of mechanical and chemical laws that enables the machine to carry out the work formerly done by worker himself. The development of machinery, however, only follows this path once heavy industry has reached an advanced stage, and the various sciences have been pressed into the service of capital.... Invention then becomes a branch of business, and the application of science to immediate production aims at determining the inventions at the same time as it solicits them (Marx, 1858).

Many historians and economists had obviously always emphasised the importance of technical and institutional change, as for example, Supple (1963). Indeed, going back to the early development of economic theory, List (1841) had strongly criticised Adam Smith and other classical economists for what he perceived as their neglect of technology and skills. In fact, Adam Smith did recognise the great importance of science and technology but did not consistently give it the prominence that List considered it merited.

List's main concern was the problem of Germany catching up with Britain, and regarding the underdeveloped countries, he advocated not only the protection of infant industries but also a broad range of policies to be designed to make possible or to accelerate industrialisation and economic growth. Most of these policies were related with learning about and applying new technologies, many of which had been applied in catching-up countries over the next century after the time of his analysis. In his book *The National System* (1841), List criticised the situation:

> Adam Smith has…forgotten that he himself includes (in his definition of capital) the intellectual and bodily abilities of the producers under this term. He wrongly maintains that the revenues of the nation are dependent only on the sum of its material capital… The present state of the nations is the result of the accumulation of all discoveries, inventions, improvements, perfections, and exertions of all generation which have lived before us: they form the intellectual capital of the present human race, and every separate nation is productive only in the proportion in which it has known how to appropriate these attainments of farmer generations and to increase them by its own acquirements… There scarcely exists a manufacturing business, which has not relation to physics, mechanics, chemistry, and mathematics or to the art of design, etc. No progress, no new discoveries, and inventions can be made in these sciences by which a hundred industries and process could not be improved or altered. In the manufacturing state, therefore, sciences and arts must necessarily become popular.

List' s clear recognition of the interdependence of domestic and imported technology and of tangible and intangible investment has a decidedly modernising. He saw too that industry should be linked to the formal institutions of science of education. Furthermore, the recent literature on 'national systems of innovation' could be described as an attempt to come to terms more systematically with these problems of social capability for technical change. List' s book on "The National System of Political Economy" might just as well have be entitled "The National System of Innovation", which will be discussed in following chapter, since he anticipated many of the concerns of this contemporary literature. Confirmingly, Table 5 and in Figure 3 can be referred to demonstrate even more the accuracy of List's argument. Also, some aspects of growth patterns can be bulleted as seen in the figure 3.

Table 5 Estimates of Trends in Per Capita GNP (1960 US Dollars and Prices 1750-1977

Year	Developed countries		Third World		Gaps	
	1	2	3	4	5	6
	Total ($ bn)	Per Capita	Total ($bn)	Per Capita	=2/4	Ratio of most developed to least developed
1750	35	182	113	188	1.0	1.8
1800	47	198	137	188	1.1	1.8
1830	67	237	150	183	1.3	2.8
1860	118	324	159	174	1.9	4.5
1913	430	662	217	192	3.4	10.4
1950	889	1054	335	203	5.2	17.9
1960	1394	1453	514	250	5.8	20.0
1970	2386	2229	800	380	7.2	25.7
1977	2108	2737	1082	355	7.7	29.1

Source Dosi et al. (1992)

- Economies have grown over the past two centuries probably faster than during any previous period in recorded history.
- However, they have grown at different and variable rates.
- The long-term patterns for the whole set of countries show an increasing differentiation, highlighted by a secular increase in the variance in per capita income.
- Catching up with forgoing ahead has been relatively rare (Britain overtaking Holland in the eighteen century; USA, Germany and others overtaking Britain in the late nineteenth and twentieth century; Japan overtaking almost everyone in the late century).
- Progress in catching up has been more widespread (Western and Central Europe in the nineteenth century; Scandinavia and Italy in the twentieth century; East-Asian countries in the late twentieth century).
- Falling behind has also been a rather frequent phenomenon.
- One can hardly identify, in general, persistent features of national growth patterns just conditional on initial performances. Close inspection of particular economies or groups of them does appear to show long-term persistence (e.g. Japan or, conversely, Britain), but the causes of the phenomenon are plausibly country specific rather than a common feature of the world economy.

Figure 3 Some Aspects of Growth Patterns

Source Dosi et. al. (1992)

The British National System

The decisive differences of British national system were based on the role of science and the role of industry. Although there is continuing discussion on that science in Britain in the 18th century lagged behind other European countries, the issue was what mattered for the industrial revolution was the prevalence of scientific culture, as displayed in the treatment of Newton in Britain and of Galileo in Italy. Therefore, there was an exceptionally fortunate congruence of science, culture, and technology in Britain, which made it possible to use science, inc1uding Newtonian mechanics, on a significant scale in the invention and design of a wide variety of new investments, machines, engines, canals, bridges, water wheels, and so forth.

For example, the British industrial revolution depended on waterpower (not on steam power, table 2) for over half a century. It was Joseph Smeaton in his papers and drawings presented to the Royal Society in the 1770s whose experimental work made possible a scientific and technological breakthrough in the design of water wheels more than doubling the productivity of waterpower. The use of iron rather than wood for the entire water wheel was made possible through Smeaton' s work as a consulting engineer for the *Carron Iron Works*, by then already the largest iron foundry in Europe. This is only one example, although a very important one, of the positive interplay between science, technology, culture, and entrepreneur, which characterised the British national system of innovation. The congruence of these four sub-systems of society extended also to the political sub-system, which promoted all of these.

Enterprises and workshops were so far conducted on a very small scale in 18th century Britain. However, the shift from cottage industry to factory production and the constant improvements in machinery were still enough to confer a huge advantage on British manufacturing firms, particularly in the cotton industry, where the combination of technical inventions, investment in machinery, factory organisation, and entrepreneur in major markets created an enormous productivity gap between Britain and others.

The significance of investment in industry together with profits from trade could not be rejected; however, this could not have taken place without a change in the culture and attitudes of the landlords and middle classes, as well as changes in the capital market. For the landlords and bourgeoisie class, the investment in trade, transport, and industry became even more important than the ownership of land. The local political initiative of landlords in promoting a wave of investment in canals in the late 18th century was exceptionally important in the early take-off of several key industrial districts whose access to national and international markets had hitherto been hindered by poor communications and transport. Furthermore, although geological factors such as rivers for navigation or waterpower and deposits of minerals or the lack of them played an important role in determining the early growth of various industries, these natural advantages were soon overtaken by created advantages such as the transport infrastructure, the location of ports and access to skills and to markets.

Lancashire enjoyed the advantage of the port of Liverpool, which was the centre of the North Atlantic trade with North America. Many economists, particularly Marshall, pointed at the external economies that resulted from many firms in the same industry located in the same industrial district where "the secrets of industry are in the air" (Foray, 1991). This is an essential part of the argument of those favouring small firm networks against large mass-production firms. In addition, this condition also lays one of the main reasons for some economists to propose that sub-national regional innovation systems have now become more important than national systems themselves. Moreover, their argument can be supported by similar economies of agglomeration applied to other industries such as pottery (Staffordshire), cutlery (Sheffield), hosiery (Nottinghamshire), or wool (Yorkshire). However, this by no means follows that the national system was unimportant or that it was simply the sum of the sub-national systems.

Undoubtedly, each of the industrial districts could flourish not only because of the specialised local advantages and institutions (markets of skilled labour, exchange of experience, trade associations, etc.), but also because of national advantages conferred by British political, cultural, economic and technological institutions. Easy access to a large and rapidly growing domestic market as well as to foreign markets, access to the capital market, and a legal system which protected property and its accumulation and access to a national market of engineering and scientific knowledge. In fact, the national and sub-national systems complemented each other.

> Britain' s economic, social, and political experience before the late 18th century explains with relatively little difficulty why she should have been an industrial pioneer. For better than any of her contemporaries Great Britain exemplified a combination of potentially growth-inducing characteristics. The development of enterprise, her access to rich sources of supply and large overseas markets within the framework of a dominant trading system, the accumulation of capital, the core of industrial techniques, her geographical position and the relative ease of transportation in an island economy with abundant rivers, a scientific and pragmatic heritage, a stable political and relatively flexible social system, an

> ideology favourable to business and innovation - all bore witness to the historical trends of two hundred, years and more, and provided much easier access to economic change in Britain than in any other European country (Supple, 1963).

Furthermore, it is hard to believe that the British industrial revolution would have been more successful if Britain had been divided into 10 - 30 separate states/cities and principalities as Germany and/or Italy. In other words, as already mentioned, Friedrich List and most of those who were concerned about the catch-up process with Britain in the 19th century, advocated a confederation of German states preceded by a Customs Union and bound together by a national railway network and other national institutions as they perceived a unitary nation-state would have a number of advantages.

The United States National System of Innovation

The supremacy of Britain was taken over by United States, whose 'national system of innovation' most closely resembled the British; in other words, after the 1870s, US started to surpass Britain in terms of productivity, economic growth etc. as seen in the figures represented in Table 6.

Table 6 Relative Productivity Levels (US GDP per hour = 100)

	1870	1913	1950
UK	104	78	57
France	56	48	40
Germany	50	50	30
Fifteen countries	51	33	36

Source Abramowitz and David, 1994

Interestingly enough, before 1870s, United States possessed rich natural resources, reputable institutions, etc., however, the insufficiency of the required transportation infrastructure for utilising these resources and the lack of scientific spirit in its institutions led to a sedentary position until the first half of the nineteenth century. In the early days, US imported much of this technology from Europe, especially from Britain, but from the very beginning, American inventors modified and reshaped these technologies to fit for American circumstances. The advent of railways and the new technologies of the late nineteenth century enabled American entrepreneurs to forge far ahead of the rest of the world. By the end of the century, American engineers and scientists were developing new products and process in most industries, which were more productive than those in Britain were.

For our purposes, we are not able to fully assess here the effects of the American Civil War (1861-65) on the development of US, which ended with the victory of

North and abolition of slavery. However, as a minimum it may be stated that the consequences of this war impacted seriously the trading partners of US, especially Britain, leading to a serious depression in British cotton industry in the following years. After the War, US achieved rates of growth well above any of what had been previously achieved by Britain. The path to the modern capitalist development was opened, owing to a combination of some essential factors, which are noteworthy to be mentioned here. Firstly, the abundance of natural resources such as forests, minerals and land, and secondly, a big and homogeneous market, which helped to use of large scale economy, advantages in mining and manufacturing industries, contributed as vital in opening this path to modern capitalist development. As these sources converged with the relatively higher price paid to the workers in the North, which had been substituted by capital resources, and skilled workers, which played an important role in the formation of American-style labour-saving, capital intensive technology investments, chiefly in mining and mineral industries, together with steel, copper, electricity, non-ferrous metals, oil and chemicals, the US manufacturing surpassed already British productivity levels by 1850 in quality of products. This fact can be observed in Table 6.

According to a number of historians, the impact of railways, coal, and iron on the growth of America undisputedly owed a lot to the huge trans-continental-scale railway construction and operation, for which three-quarters of all produced steel had been used in 1880. Moreover, when railways were diffused with telegraph lines throughout the continent, not only many industrial sectors, but also agricultural sector gained an import advantage, especially in terms of speed and reliability of transport and communications. This new regulatory system, its certainty and volume, not only effected positively growth of the factory system, wholesale and retail business in the America (Fogel, 1964), but also institutional change such as management, competition, rules of finance and labour market etc. (Chandler, 1965)

3.2.1. Economic Growth and Diffusion of Technology

As illustrated in 3.2., the importance of ' foreign' technology and its international diffusion has been historically a well-recognised factor in the industrialisation of both Europe and the United States in the nineteenth century, and even more strikingly of Japan in the twentieth century. That importance emerges stronger daily from the evidence with regard to the rapid industrialisation of the so-called ' newly industrialising countries' such as South Korea, Taiwan, Singapore, China, Malaysia, and Thailand.

The international diversity in growth performance of countries demonstrated the importance of path-dependent development, with many bifurcations and possibilities of 'locked-in' effects. In fact, the situation shows paradoxical characteristic; previous capital is needed to produce new capital, previous knowledge is needed to absorb new knowledge, skills must be available to acquire the new skills and a certain level of development is required to create the agglomeration economies that make development possible. In other words, the logic of the dynamics of the system that the rich get richer and the gap remains and widens for those left behind.

The question is whether these constraints are always equally formidable or whether their intensity varies in time with some increasing and some decreasing, thereby opening 'windows of opportunity' to developing countries. According to Perez and Soete (1988), it is clear that through the 'use' of imported technologies these countries would acquire some comparative industrialisation advantage in low-tech mature products and industries. At first sight, the choice of such products as a point of entry might appear to be the only one to initiate a development process and establish a process of economic growth. However, mature products are precisely those that have exhausted their technological dynamism, there will also be risks of getting 'trapped' in a low wage, low skill, low growth, development pattern. Technological catching up will only be achieved through acquiring the capacity for creating and improving as opposed to the simple 'use' of technology.

Under these conditions, it can be expected that the vast majority of new technologies will originate primarily from within the technologically most advanced countries. However, there are good reasons to expect that the internal national diffusion of such major new technology might well be hampered by various factors. The possible previous investment outlays in the existing technology, combined with commitment from the management, the skilled labour force and even the 'development' research geared towards improving it, might all hamper the diffusion of the new technology to such an extent that it will diffuse more quickly elsewhere, in a country uncommitted to the old technology, both in terms of actual production and investment.

Even after the WW II, when the OECD organised many European missions to study the productivity gaps between European and American firms, they stressed the scale of plant and size of domestic market as two of the biggest comparative advantages of US firms. However, catch-up by Western Europe took place between 1950-1975, although it certainly cannot be attributed uniquely to scale economies and market enlargement. European research and development activities, technology transfer, education and training, and management techniques were all greatly improved. Investment by the US firms in Europe, and the by the European firms in the US also facilitated the technology and management techniques. All these factors were necessary even to achieve the scale economies themselves.

According to Gerschenkron (1962), the pioneering firms and countries had already established a growing world market so that the catch-up firms did not have to face all the uncertainties, costs, and difficulties of opening up entirely new markets. Moreover, his theory of late-comer advantages stressed that the pioneers could not possibly start with large plants, whereas the late-comers could move very rapidly to large-scale production, while their mature competitors might be burdened with smaller plants embodying now obsolete technology.

Gerschenkron's explanation was endorsed by the study of Jang Sup Shin (1996) in his study of the Korean steel and semiconductor industry, arguing that the plant-scale advantages of the Korean producers. In addition, he underlined that a successful catch-up process could not be achieved unless a number of institutional changes are mastered, particularly in education, training, and R&D.

Another problem of developing countries has been highlighted by Bell and Pavitt (1993), who advocated that countries, which simply install large plants with foreign technology and foreign assistance without experiencing the build-up phase in the technological arena, often face with under-capacity working ratios, and low output capital. Furthermore, Perez and Soete (1988) provided a more general theory of the science and technology infrastructure as a prerequisite for effective catch-up. They not only showed that even the costs of imitation could be rather high in the absence of a sufficient infrastructure, which is taken for granted in mature industrialised countries, but also the windows of opportunity in the acquisition and assimilation of technologies, provided the catch-up countries followed appropriate social, industrial and technology policies.

Finally, two points can be attributed to the late-comer advantages. First, the plant scale economies of a particular historical period were not necessarily characteristic of all industries or of other periods; for instance, aircraft or drugs that scale economies in design and development costs were much more important than plant-scale economies in production (Perez and Soete 1988). Second, as the theory of traditional international trade has always stressed, late-comer countries will usually enjoy labour cost advantages, which may even increase due to the wide disparities in world-wide per capita incomes.

In addition, although the geographical and cultural proximity argument is controversial, it also seems to be the case that geographical and cultural proximity to the countries that have led either in forging ahead or in catching up has a considerable effect on rate of catch-up. More clearly, Britain was the first that had been caught up and overtaken by neighbouring European countries and by countries partly populated by British and other European immigrants (the United States, Canada, Australia, etc,). The most successful catch-up countries in the late 20th century have been those that are geographically (and in some respects culturally) close to the 1eading catch-up country of the 20th century, i.e. Japan.

Alternatively, although there are some major advantages for the late-comer countries, also in some circumstances late-comers starting from a very low level of productivity could even enjoy growth rates much higher than the established leading countries. In other words, it does not always necessarily follow that late-comers will always tend to converge with the leaders, which mainly depends on social capability for technical and institutional change, i.e. on the national systems of innovation and on the nature of the new waves of technology pervading the system etc.

As a matter of fact that the scarcity of such successful examples illustrates how ' non-automatic' and exceptional such processes of effective technological catching up and leap-forging have been. The use of foreign, imported technology might appear as a straightforward ' industrialisation' shortcut, but the effective assimilation of foreign technology is actually difficult and complex. The crucial question will be the ' absorptive capacity' of the countries and the domestic firms.

If we follow the taxonomy put forward by Freeman and Perez (1988), the ' life cycle' of such a techno-economic paradigm is composed of a series of interrelated technology systems. It is clear that it is the interconnection between technological systems, which generates and diffuses knowledge, skills, and experience, which are of widespread and general use. In this view, the present transition period is identified with a change in techno-economic paradigm, and this will affect the whole range of technology systems that have evolved and matured under the previous paradigm. Most of them will be profoundly transformed as the new information intensive, flexible, systemic, microelectronics-based paradigm propagates across the productive system. Mature industries reconvert, mature products are redesigned, new products and industries appear and grow, giving rise to new technology systems based on other sorts of relevant knowledge and requiring and generating new skills and new local and infrastructural advantages.

What this means for developing countries is that during periods of paradigm transition a temporary window of opportunity is open for entry into new industries. First of all, the failure of the (international) patent system to provide effective protection for inventions and innovations in electronics has meant, however, that imitation, the competing away of the innovation/monopoly profits, and the ' swarming' effect have all proceeded much more rapidly, both nationally and internationally. In addition, the specific capital-saving potential of information technology seems to be of relevance to countries where growth has been hampered by general capital shortage. Lastly, the ' wrong' skills and ' irrelevant' experience could well amount to a more significant bottleneck and diffusion retardation factor in the advanced countries than in many industrialising countries.

However, the potential advantages of developing countries are subject to a number of changing factors such as its history of development, natural resources, social, cultural, and political factors. Furthermore, taking advantages of the new opportunities and of favourable conditions requires the capacity to recognise them, the competence, and imagination to design an adequate strategy, and the social conditions and political will to implement those. Anyhow, besides the conditions mentioned, the chance of any developing country is mainly affected by the ultimate shape taken by the socio-institutional framework at the international level.

Therefore, the import of foreign technology should not be taken only in terms of a position of complete autarchy in S&T, but it should also be considered struggling to be completely independent in every single branch of research and development would be ruinously expensive and almost impossible for all but the largest super powers. The mechanisms for the international transfer of technology are of the greatest importance for policy-makers in the developing countries. In many countries, the capacity to receive technology from outside imperatively requires some independent indigenous science base to an extent, and also a variety of other scientific and technological services are needed as well as R&D, like information services, consultancy services, project surveys, testing facilities, and training organisations. Thus, the present period has always been and continues to be particularly favourable for attempting a jump in development of whatever size is possible; however, without this, there cannot be any independent long-term cultural, economic, or political development for any developing country, which demands a complete reassessment of each country' s conditions in the light of the new opportunities.

CHAPTER IV

4. NATIONAL INNOVATION SYSTEM and TURKEY

The ability to create, distribute, and exploit knowledge has become a major source of competitive advantage, wealth creation, and enhancement of the quality of life. These changes imply that science, technology, and innovation today are fundamental to improve economic performance and social well-being. However, if governments want to gain the benefits from this transformation, they will have to put the right policies in place. Limits on public spending, increased competition and globalisation, changes in the driving forces of the innovation process, and a better understanding of the role played by science and technology in economic performance and societal change, have led governments to sharpen their policy tools.

This chapter can be perceived in two parts, starting with an exploration of the role of science, technology, and innovation in the development of countries at the outset, and discusses the role of government in fostering scientific and technological progress for economic growth and greater social well-being. Subsequently in the second part, based on the former discussions and arguments in the first part, Turkey's National Innovation System, and accordingly, Vision 2023 Project will be evaluated in a comprehensive approach.

4.1. Historical Evolution of Science, Technology and Innovation Policy

Over the past ten years or so, there has been a revolution – a 'paradigm shift' – in the way we understand the vital role of science, technology and innovation. This section of thesis distinguishes among three main terms in science, technology and innovation policies regarding their development and relation to society. These three terms are: 1) Science-defence term; 2) Technology-industry term; and 3) Society-innovation term. Each of these perspectives developed over the course of a ten to twenty year period after World War II, and each is not only tied to a specific policy context but also they can be seen as simultaneous perspectives that have been competing with one another during the past sixty years. However, analysing before explain these three terms, it would be useful to give Friedrich List's -who clearly anticipated many contemporary theories on national system of innovation- arguments for purpose of discussion.

4.1.1. Friedrich List "National Systems"

The formation of British Industrial Revolution did certainly set a strong motive for profit gains. On the other hand, realisation of the possibility to increase profit by export-aimed production had been the fundamental dynamic of the British Industrial Revolution (Hobsbawm, E.J., 1968); a dynamic, which initiated the vital condition of the process, the development and expansion of production. Numerous factors brought about this process, but the most important of all was the technological innovations in methods and machinery/equipment used for production, and diffusion of these innovations in the entire production sector. As stated above, British mechanists and industrialists, i.e. engineers of the era in a sense, conceived widespread innovations in almost all types of production machinery. These innovations created a source for development of transportation tools, which played a significant part in the expansion of the market, and increase in production. Expanded industry became capable of innovating itself into a technologically higher level and increased its productivity capabilities permanently. This capability grew to be the basic reason of Great Britain's unquestionable superiority in the world markets.

Friedrich List was the first to bring up this notion. He could see that British Industrial Revolution created superiority for Great Britain and that the important factor of this advantage was the technological capability. List conceptualised the National System of Political Economy and developed the basic resources of his argument in America between 1825, 1832, while he was exiled for political reasons. Moreover, besides the protective policies for national industry, the rich natural resources and the importance given to education were evidently rather effective for United States in the process of catching up with Great Britain.

According to Hobsbawm (1968), agricultural production was dominant in German economy, despite an extremely weak industry compared to Great Britain, which overwhelmed the world markets with a share of approximately 20% in world trade. List founded his theory upon a comparison of the conditions that Germany and Great Britain were experiencing, where he put a considerable emphasis on

Germany's learning and indigenizing this new technology, diffuse this technology to the relevant fields of economy, and utilise it. Moreover, he also put forward that for Germany to take part in international competition, there was the necessity of building up the capability to reproduce this technology in an upper level.

If we conceptualise the argument of List in today's terms; two concepts would be pioneering; 'innovation' and 'national innovation system'. As pointed out above, List considered that technology provided superiority to Great Britain; and Germany had to acquire innovation capability, just like Great Britain. To achieve this target, Germany should accomplish "The National System of Political Economy", which might have been entitled "The National System of Innovation" just as well. A comprehensive explanation of List's theoretical analysis and technology policy oriented from this analysis is found in the works of a well-known Schumpeterian theoretician Christopher Freeman, who has an important place in today's economy. Freeman says (1995);

> List could not be expected to foresee the whole changes took place in world and national economies after 150 years. List could not foresee especially the increase in professional R&D activities, which were managed by the industry itself. This orientation in industry, has changed the concept of ` national innovation system` compared to List` s era. Industry's establishment of its own industrial R&D unit was first seen in Germany in 1870. It was German chemical industry, which first noticed that a systematic and professionally managed research activity would bring profit together. The great success of German chemical industry has later directed other countries` chemical industries and electrical machine, electrical tool producing industries towards the same direction. This motive of establishing professional R&D units, which stated at the end 19^{th} century and the beginning of 20^{th} century, has later became an important characteristic of big firms.

Briefly, it is obvious that especially after Second World War, innovation process became more complicated compared to List` s era; and in order to catch up with the world technology, countries, which entered in the industrialisation process after Great Britain, regardless of their size, had developed policies and applications compatible with List` s arguments. That is why every country looking for a worldwide dominancy in future and aspiring to sustain its socio-economic development through establishing competitive advantage and increasing its market shares, has a national policy, which emphasises targeting competency in technological innovation or increasing the level of this competency.

As broached earlier, arguments on the important role of science and technology were also suggested by the Nobel Prize Laureates in economics, Kenneth Arrow and Robert M. Solow. Arrow contended that science requires public support as it is associated with economic risk (market failure). Thus, according to Arrow, science is characterised by a fundamental 'uncertainty' as its results cannot be predicted, by its 'indivisibility' among economic actors as it cannot be divided among them like pie, and as it is difficult to be 'appropriated' economically, since information/ knowledge easily flows from one actor to another – the imitation problem. The existence of high economic risk, he argued, implies under-investment in science by private firms, thus providing a rationale for public support. Solow had investigated the growth in output per worker in USA in the period from 1909 to 1949 and he found that 87.5 percent of the growth could not be explained by an increase in capital per worker, as opposed to the traditional reasoning; however, a residual factor had to be assigned what he put forward as 'technology'. This was not very a convenient way of explanation, since economic theory did not generally consider technology within these models. Nonetheless, the argument suited well the spirit of the time –that science and technology were outstanding forces contributing to growth and prosperity.

4.1.2. Science-Defence Term (1950-1975)

Figure 4 Science-defence Term (linear model)
Source Durgut (2003)

The period starting from at the end of the World War II to 1970s onwards, could be summed up with the motto: 'science for the sake of science', 'science and technology shape society' and the concept of 'defence technology'. These perspectives evolved out of an atmosphere of science and technology optimism in the years after WW II and continued throughout the cold war period. Science and technology were, for the first time globally defined in modern history, considered as forces of socio-economic change that made a difference for society and economy. One important contribution to these perspectives was made by Vannevar Bush who was director of the OSRD and the U.S. President (Roosevelt)'s advisor for scientific research and development. His 1945 report, 'Science, the Endless Frontier' is a source of inspiration for the modern funding system for science. Bush argued that a 'basic science' would eventually have positive consequences for the economy. According to him, science should not be targeted directly by government; rather, funding should be determined by scientists themselves through a system of peer review.

In addition, his argument was based on the 'defence technology' perspective, according to which the consideration of research and innovation as a linear process (Figure 4) is a fundamental feature. Under this perspective, governments are reckoned as the main client of R&D activity. Large-scale national programs, justified primarily by political criteria, serve to fund the technologies that state needs for its public and military sectors. In the selection of research projects, two main criteria were taken as ground rules: scientific excellence, and political and/or military interests. The benefits of this perspective to industry and society are justified only by direct and indirect spin-off from investment in basic and military R&D. In fact, strategic military projects became the reason for important scientific projects that were managed, financed, and realised in state laboratories, as in the case of Manhattan Project, which ended up with atomic bomb, radar, rocket, ENIAC, etc. (Türkcan, 1998). Table 7 gives a compact idea on the importance of military projects, comparing the intervention of state into science and technology area and R&D expenditure of the US and Britain before and after the WW II.

Table 7 R&D Expenditures of the US and Britain before and after WW II

	Industry			State (civil)			State (military)		
	1937	1955	1962	1937	1955	1962	1937	1955	1962
US	61	920	1800	20	140	960	5	710	2800
GB	3	65	213	3	36	139	1.5	214	246

Source Caracostas, P and U. Müldür (1997)

It can be deduced from Table 7 that the expenditures of US and Britain in the area of military R&D projects, which were financed by public sources, increased by 140 times in 1955. The figures on the table set a clear reflection of the war psychology as the national security reservations of the states had been expressed in this situation (Dore, 1989). In addition, the period can be divided into two main terms accordingly: Science Push Model (1950-1965), Market Pull Model (1965-1975)

Science Push Model (1950-1965)

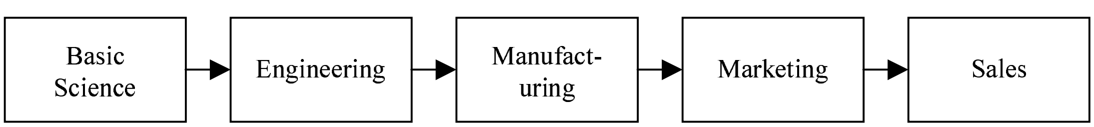

Figure 5 Science Push Model
Source Erik Arnold (2001)

During this term, demand has been much more than the production capacity. The new technological sectors were the main sources of the economic growth. The science, technology, and innovation strategies were mainly focused on R&D activities and production. Thus, this term is characterised with 'science push' model (Henderson, 1983). As seen in Figure 4, industry and society are justified only by the direct and indirect spin-off from investment in basic science. In addition, governments are the main clients of R&D activities and the projects were selected based on two main criteria; scientific excellence, and political & military interest. However, this model has been criticised in two central aspects. First, there is too much concentration on R&D, which veils the importance of other inputs. Second, there is a lack of feedback links in this model because of its linear structure.

Market Pull Model (1965-1975)

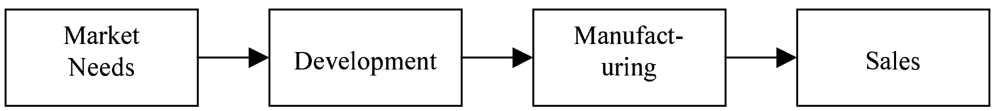

Figure 6 Market Pull Model
Source Erik Arnold (2001)

Suitable conditions for economic development nourished in 1960s. Firms tried to cope with increasing competition via diversification of their products. As seen in Figure 6, the sourcing for these new products were supplied by the market demand itself, which has been regarded as a booster of the innovation process. Thus, this model is called 'market pull' (Kaplinsky, 1989). However, there are three criticisms to this model. Similar to the previous model, the emphasis is concentrated rather on one aspect, which is 'market activity' in this model. The other inputs of the innovation process are not taken into account. In addition, the importance of scientific and technological innovations is ignored. Finally, again, there is a lack of feedback links in this model, too, due to its linear structure. The problems with linear model of innovation have been analysed by Kline and Rosenberg (1986). As noted earlier, there is a complete absence of feedback paths, which can also be seen briefly in Figure 7. As indicated by Kline and Rosenberg (1986), "the shortcomings and failures" that are "part of the learning process that creates innovation" signify that in both radical and incremental innovation, "feedback and trials are essential". Another problem with linear models is their approach to research as ' applied science' . Contrarily, basic scientific research does not always lead to the design of innovations.

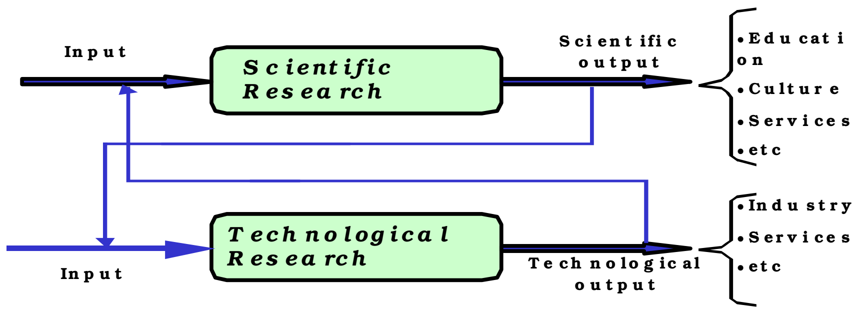

Figure 7 Simple S-T Relation

Source Durgut (2003)

Rather, "problems that are thrown up by the processes of designing and testing new products and new processes often spawn research... true science...and have in some instances even given rise to new branches of mathematics" (Kline and Rosenberg, 1986). As a result, the key and common characteristic of these models is the comprehension of research and innovation as a linear model, and many institutions in the USA and Europe have been established during this term under the dominance of this line of approach.

4.1.3. Technology-Industry Term (1975-1995)

The shift from 'science and technology shapes society' and 'defence technology' perspectives to 'applied research' and 'society shapes science and technology' perspectives had been dictated by three powerful and influential factors: firstly, the end of the 'thirty glorious years' heralded by the succession of oil crises; secondly, 'the spectacular industrial rise of Japan and Germany which had not really operated a science and technology policy based on the pairing of defence and science' (Caracostas and Muldur, 1998) and thirdly the explosion in ICTs. With the cease of the previous approach, the new latter emerged in an environment where there was increasing competition in new areas, such as electronics, computers, aeronautical, etc., and it has been accepted as an objective new approach. Therefore, this new, 'technology-industry' approach became more dominant than the science-military approach.

The new approach favoured two new and concomitant directions in terms of business sector. On the one hand, the objective was increasingly tending towards help to develop the competitiveness of the so-called strategic industries, since these guaranteed the economic and political independence of Nation States. On the other hand, the preferred means of operation was to promote the leading-edge technologies. Instead of ‘basic research’, there was an expansion of ‘contracted research’ in public R&D programs towards these new ends. During this phase, there has been a radical change in the nature of the role and/or functions of government in R&D.

Government started to become a ‘partner to industry’ together with shift in the selection criteria of projects towards the extent of the proposed impact on industry and of the contribution to competitiveness. In this term, many planning institutions and offices were established in order to make ex-ante assessment of S&T choices and ex-post assessment of results, hence industry representatives started to be invited in the process of ex-ante, which was a new development demonstrating the changing mentality. Likewise, the proportion of total state-funded R&D expenditures started to decline. However, the reason of this decline was not public spending; on the contrary, it resulted due to the huge increase in the private sector investments in R&D. Interestingly enough, during this term, military expenditures did not decrease, but even increased in some OECD member countries, as in US.

The academic discussions emphasised more on the social force external to S&T. Science and technology were to be considered in the light of the social, economic, and political interests and the concerns of the wider population. There were two particular lines of reasoning; one argued in strategic and political terms that S&T should be more explicitly linked to social forces, while the other emphasised a sociological and academic approach, seeking to examine and conceptualise links between social forces and S&T.

Thus, the main idea of the ‘society shapes science and technology’ and ‘applied research’ approaches was a perception of technology, which is open to external forces and negotiation. Analysts stressed that technical change is not neutral but biased by social and economic forces; therefore, civil groups could and should be empowered and integrated into decisions concerning S&T. The period can be divided into two main terms: Coupling Model (1950-1965), and Integrated Model (1985-1995).

Coupling Model (1950-1965)

As seen in Figure 8, the relationships among market, firm and science-technology area are shown as connected to each other in this model, which suggests that the feedback links are taken into account. However, although the feedback links are emphasised, the dynamics of the process still display linear characteristics (Neely and Hii, 1988)

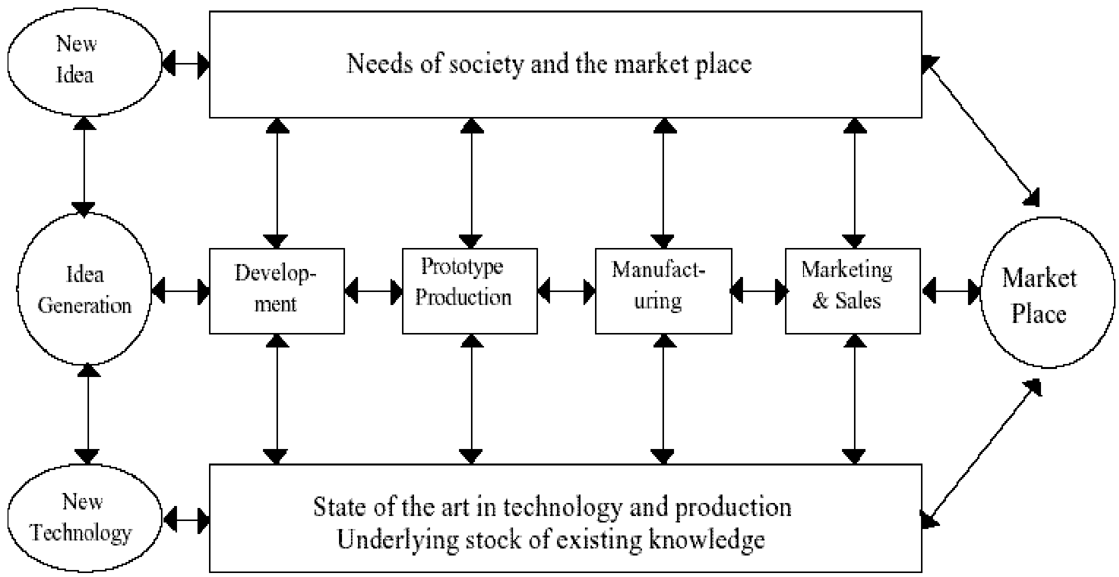

Figure 8 Coupling Model
Source Neely and Hii (1998)

As seen in Figure 8, the relationships among market, firm and science-technology area are shown as connected to each other in this model, which suggests that the feedback links are taken into account. However, although the feedback links are emphasised, the dynamics of the process still display linear characteristics (Neely and Hii, 1988)

Integrated Model (1985-1995)

Throughout the 1980s, the studies of Japan on electronic and automobile industries became the focus of this new model, called integrated model (U.S. Department of Commerce, 1990). This model largely depends on the integration of functions and paralleled activities between functions. In addition, the encounter of the functions such as R&D, marketing, production departments etc. provided knowledge sharing, which helps the more efficient use of the knowledge (Mody, 1989).

4.1.4. Society-Innovation Term (1995-)

At the outset of the first half of the last decade, a new approach started to emerge, stemming out from two strands of argument; “quality of life”, as put forth by

Freeman, and "sustainable development", as suggested by M. Crow. The underlying reasoning of these discussions can be summarised with five major factors: the collapse of the communist block and of the political pressure to over-invest in military R&D; the appearance, for the first time since 1945, of a trend towards lower military R&D spending in the developed countries; increasing globalisation of the economy; the rise of structural unemployment, and new social values and concerns (environment, quality of life, health, pensions, etc); the gradual impoverishment of states and growing public mistrust of science and its consequences.

The general public opinions in developed countries have started to dissociate from the hot debate of previous decades, which was whether a state presence - more or less - is desirable. Today, there are very specific expectations or demands from public research and innovation policies. That is to say, it calls for responses to its most pressing problems such as unemployment, health, and quality of life. The former motives of defence, development of know-how (or its derivatives such as know-what, know-who, etc.), and industrial competitiveness are no longer sufficient enough reasons to justify spending large amounts of public money on R&D in a climate, where government resources are structurally on the wane compared with the spending of multinational enterprises.

Inevitably, a policy of this kind will be centred on innovation, which is defined as "…transforming an idea into a marketable product or service, a new or improved manufacturing or distribution process, or a new method of social service" (TÜBİTAK, 1999), and as the preferred instrument of economic and social change. One basic advantage of pairing off society and innovation is that public policies can be revitalised without earlier objectives being abandoned. Industrial competitiveness will no longer be an objective but a means of increasing the contribution of science to growth, employment, and rapid dissemination of innovation. It is also a fact that whole innovation process must be encompassed to achieve socio-economic targets. Needless to say, governments will always act as a partner of industry, not to help companies maximise their profits but to help them market those innovations, which are most beneficial to society.

The instruments used for increasing national innovation capability to perform better have to settle the balance between market conditions and societal needs. As seen in Figure 9, the necessity of balance can be explained by two reasons.

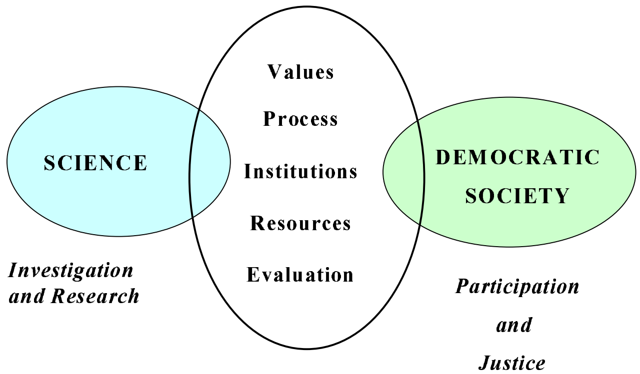

Figure 9 New Contract After 1995
Source Durgut (2003)

The first reason is that within capitalist economic systems, markets are considered effective mechanisms for articulating and satisfying most economic needs or demands; however, it is clear that not all the specific societal needs are likely to be met by the market. The second reason is that traditional government support for research and subsidies for technology development operate on the supply side, seemingly distant and somewhat disconnected from the satisfaction of immediate social needs.

In this context, the state/government acquires a very important task regarding management of information within the economic structure. In order to activate the innovation potential, which fosters economic growth, technology policy should be a complementary part of the economic policy. Policies that require to be considered together with technology policies can be stated in essence as; the innovation-based competitive policies, which increase competitiveness and at the same time, would help common research; education policies that would supply the required human potential; regulatory policies that would decrease red-tape bureaucracy and institutional rigidity; financial and monetary regulations that would support capital flow to small firms; communication policies that would help and increase the dissemination of information/knowledge; and foreign investment and trade policies that would foster the dissemination of technology on the international scale. Consequently, the mottos of the term can be pronounced briefly as 'science for society' rather than 'science for science's sake' or 'society, the endless frontier' rather than 'science, the endless frontier' and consequently the features and topics of society – innovation term can be summarised as in Table 8. Therefore, the important developments in the area of science, technology, and innovation after the World War II, which are discussed so far here, could be summed up by Figure 10 and Table 9.

Table 8 Features and Topics

FEATURES	TOPICS
Information society (knowledge based economy, learning society, complex systems, uncertainty etc.)	Sufficient human and capital resources
Globalisation (opportunities and threats in trade, investment, production, research etc.)	Capability for innovation/ creativity
Competition and collaboration (networking, clustering etc.)	Learnability
Total policies for innovation (Legislative reforms, communication, foreign investments, labour market etc.)	Foresight
Innovation policies (local, regional, national)	Socio-cultural context of S&T

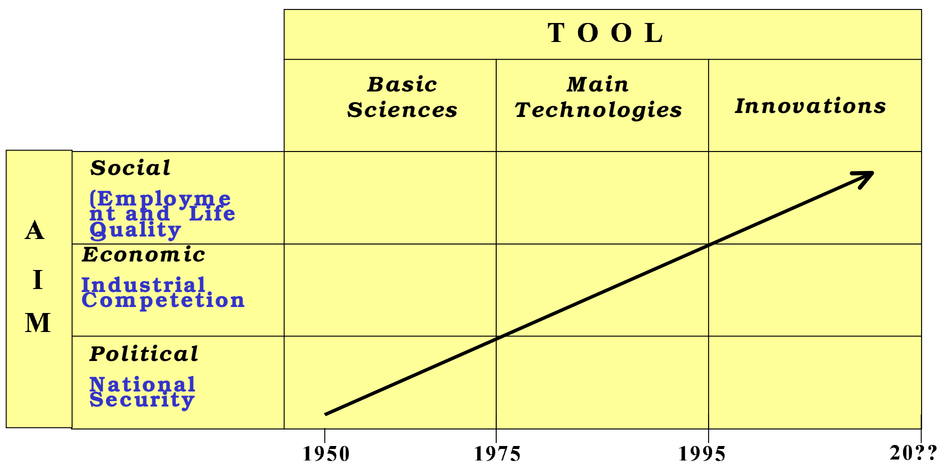

Figure 10 Research and Innovation Policies

Source Durgut (2003)

4.2. Innovation System

The etymology of the word ‘innovation’ derives from Latin word "innovare", which means ‘making new things’. By definition, OECD describes the term ‘innovation’ as ‘the successful marketing of new or developed products, the use of new or developed processes or equipment for commercial purposes, including scientific, technological, commercial, and financial steps for presenting/adding a new approach to a social service’ (OECD, 1981). Another explanation provided by OECD, illustrates ‘innovation’ as a concept that denotes both a process and a result. Again, ‘innovation’, as a process, expresses the transformation of an idea to a marketable product or service, to a new or developed method of manufacture or distribution, or to a new method of social services.

Table 9 Specialities of All Terms

Period	1950-75	1975-95	2000 and after
Main Objective	Political	Economic	Social
Determining factor	Defence	Industrial Competitiveness	Employment &quality of life
Geographical Scale	National	International	World-wide
Model of research process	Linear	Linear (creation &dissemination	Interactive and systematic
Choice of measures	Science-led	Technology-led	Demand-led
Nature &determination of priorities	Basic R&D centred on spill-over	Pre-competitive R&D &indirect support for innovation	Targeted R&D (incl. Socio-economic aspects) up to commercialisation of innovations
Ministerial leadership	Defence, education &research	Techno-industrial (top down)	Socio-politic (bottom-up)
Main technologies funded	Nuclear, aeronautical, chemistry	Electronics, computers & telecommunications	Hybrid science & technologies, combined to address specific problems
Implementation	Public-sector research bodies	Programs of incentives & cooperation	Task Forces, interdisciplinary programs and projects
Method of funding	Administrative	Techno-administrative	Techno-financial
Method of project assessment	Scientific assessment by peers	Scientific assessments by peers & users	Assessment of financial aspects & socio-economic impact
Principal selection criteria	Scientific excellence	Scientific excellence & contribution to competitiveness	Contribution to needs of society & industry
Intellectual inspiration	Vannevar Bush (1945)	OECD, Japanese VLSI&5th generation computer programs	Gibbons-Nowotny, Kodama, Nelson-Lundwall-Freeman, social shaping of technology
Assessment of measures	Assessment of scientific impact (perhaps)	Assessment of Scientific & technical impact	Assessment of socio - economic impact & ongoing strategic monitoring

Source Caracostas and Müldür (1997)

The interesting point of the OECD definition of innovation is that there is an emphasis on ‘marketability’, resulting from either incremental innovation or radical innovation. In addition, there is no mention of qualifications in the definition of the concept; whether it results from traditional technological areas or newer technologies, it has to end up with marketing. Furthermore, according to a different variation of the definition by EC (1995), innovation is portrayed as the renewal and enlargement of the range of products and services and the associated markets; the establishment of new methods of production, supply, and distribution; and the introduction of changes in management, work organisation, and the working conditions and skills of the workforce. Depending on all these definitions, a general characterisation of innovation can be derived as such:

- Innovation is a process which consist of market and market institutions and creative and interactive process;
- Innovation is based on scientific progress;
- Innovation is not only related R&D. The centre of technological innovation is consisted by firms, but they cannot act by individually;
- Innovation consists of creative use of different knowledge, which resulted from market and social demands. (OECD/DSTI/TIP, 1988)

As we have already mentioned in neo-Schumpeterian models, technological factors are the point of the focus. Inevitably, technical change is then regarded as a continuous process resulting from innovations, namely, incremental and radical innovation. Incremental type of innovation usually emerges continuously in any industry and services, depending on the combination of demand pressures, socio-cultural factors, technological opportunities, and trajectories. Typically they occur due to the outcomes of inventions and improvements, which are suggested by people engaged in the production process e.g. engineers or users. Although their combined effect is extremely important in the growth of productivity, which can be inferred from input-output tables and steady growth of productivity, no single incremental innovation has dramatic effects and they may even pass unnoticed. Contrary to incremental innovation, radical innovation entails discontinuous events and resulting from research and development activities particularly in government, university, and private sector R&D laboratories today. For instance, there is no way to obtain nuclear power by incremental improvements in a coal power station. Radical innovations are unevenly distributed over sectors over time and whenever they occur, they cause a surge of new investments, called 'booms'. These innovations usually involve a combined product, process, and organisational innovation. Another important concept on innovation, 'diffusion of innovation' is identified by OECD as "it is diffusion of innovations via either market or non-market canals. Without diffusion, there is no economic value and effect of innovation" (OECD, 1992). Thus, the main components of diffusion contain; innovation - an idea, practices or objects; potential users; decision-making process of the users; and the knowledge flow between producers and users. The key parameter regarding the diffusion of innovation is the proportion of diffusion of innovation with respect to its speed (diffusion of innovation/speed). This proportion of diffusion of innovation increases or decreases depending on the benefits it provided to the society, while the speed of innovation increases or decreases depending on its cost. Another determinant of the ratio of diffusion of innovation is its competition capacity with current or old values and experiences. This ratio gives an idea on the ratio of users that accepted innovations, which show differences from one society to another (Rogers, 1995). According to Carlsson (1997), there is a close relationship between innovation and economic, political, and social features of the society. This view is also pointed out by Christopher Freeman (1983) "…virtually all economists, neo-classical, Keynesian, Marxist, Schumpeterian or whatever, accept the point that productivity growth depends very heavily on the introduction and efficient diffusion of new and improved processes and products in the economic system". According to Freeman, we experience now some radical changes in 'techno-economic paradigm' and in new generic technologies, but above all, the new information and telecommunication technologies, which create this deep-going transformation, enable us to change the technology base of labour process in order to enhance the productivity.

Prior to 1990s, the R&D system was regarded as a source of innovation and the analysis of the technology policies, and its performance largely depended on its inputs (e.g. number of researchers or R&D expenditures) and outputs (e.g. patent). However, various studies on industry, R&D and innovation, altered this opinion. As suggested earlier, it was realised that main sources of incremental innovation are engineers and technicians employed in production departments, whose performances were related directly with the type and efficiency of their organisations. Moreover, the development of most products and services were influenced in essence by the interaction between market and firms. Although the chief determinant of radical innovation has been R&D activities, it is considered that other departments in firms also have significant roles in this process (Göker, 1988). In other words, traditional indicators cannot be sufficient in explaining innovation, growth, and productivity trends. These indicators only take a snapshot photograph of the technological performance, but they are short of illuminating the relation between actors of innovation regarding their structure and performance. The role of people and institutions with respect to their relations and networks are accentuated more in the process of technological development during Society–Innovation term (Edquist, 1997). According to Göker (1998), the comparison between the USSR and Japan economy (Table 10) is pertinent in demonstrating the systematic character of innovation system. To put it briefly, despite the advantages USSR had in science and technology area, they were not able to generate the interaction of science, technology, and production, which added to the process that ended up with the collapse of USSR. On the other hand, although Japan was defeated in the WW II, it was understood how essential the interaction among S&T and production was, which contributed to their being one of the pioneering actors in today's economy. Moreover, the systematic character of the innovation is recognised as becoming more important in the process of spin-off and performance of technology (Carlsson and Jacobson, 1999).

There are a number of reasons for this increase in interest: first, the theoretical essence of the innovation systems approach allowed for a realistic analysis of innovation processes; second, the empirical studies yielded valuable insights into the determinants and the organisation of innovation processes at different levels; third, innovation system studies have proved to be highly relevant to technology and innovation policies; and finally, it is evident that industrialist countries shifted their policy designs away from the elimination of market failures towards improving the organisation of innovation processes.

Table 10 Comparison of USSR and Japan

Japan	USSR
High GERD/GNP Ratio (2-5%) Very low proportion of military/space R&D military/space (<2% of R&D)	Very high GERD/GNP Ratio (*c.* 4%) Extremely high proportion of R&D (>70% of R&D)
High proportion of total R&D at enterprise level and company-financed (approx. 67%)	Law proportion of [Oral R&D at enterprise level and company-financed (<10%)
Strong integration of R&D, production and import of import of technology at enterprise level	Separation of R&D, production and technology and weak institutional linkages
Strong user-producer and subcontractor network linkages	Weak or non-existent linkages between marketing, production and procurement
Strong incentive to innovate at enterprise level involving both management and workforce disincentives affecting both management and workforce	Some incentives to innovate made increasingly strong in 1960s and 1970s but offset by other negative
Intensive experience of competition in international markets competition except in arms race	Relatively weak exposure to international markets

Source Freeman (1987)

Moreover, there is a change in the acceptance of innovation system process with respect to its conditions and environment, the reasons of which can be put forth concisely under a number of reasons. First, the dependency of innovation system on the interaction between universities and firms is increasing. Second; the networks and collaborations of firms gained more significance compared to the past, and third, firms are much more impelled towards innovation due to the increasing competition in the market. Another reason is that the change of organisational structure plays a vital role to gain advantages in technological change; and, fifth, tacit knowledge is a key factor in terms of efficiency of innovation system. Additionally, the attaining of tacit knowledge became increasingly dependent upon interaction, multi-disciplinary studies, lifelong learning, and free circulation; sixth, changes have also occurred at the firm level. Traditionally, large firms were often regarded as the main driving forces of innovation, whereas, the small firms are increasingly playing a key role today. Small start-up firms, which are more flexible and unencumbered than large established firms, are important sources of new ideas and innovation, and may have an advantage over larger established firms in emerging areas where demand patterns are unclear, risks are large, and the technology has yet to be worked out. In addition, the lack of skilled personnel is a key barrier to innovation that needs to be addressed. Countries also need to address at education, skills upgrading and human resource management at the domestic level. Creativity, teamwork, and cognitive skills are required, as economies become more innovation-based. Therefore, the human capital has always been a key factor in the innovation process, however, international mobility of skilled workers now gained an increasing importance together with efforts to attract or use skilled human resources from abroad in consequence. Finally, the role of SMEs, particularly of those engaged in new technologies, is increasing in development and diffusion of new technologies (SPO, 2001). The emergence of innovation system approaches and their characteristics have been dealt with by Edquist (1997). He identified innovation system approaches and their characteristics, deriving several conclusions, analysed below.

They place innovation and learning process at the centre of focus; which is based on the understanding that technological innovation is a matter of producing new knowledge or combining existing elements of knowledge in new ways so that a 'learning process'. *They adopt a holistic and interdisciplinary perspective;* they are holistic in the sense that they try to encompass a wide array-or all- of the determinants of innovation that are important. They are interdisciplinary in the sense that they include not only economic factors but also organisational, social, and political factors. *They employ historical perspectives;* since process of innovation developed over time and include the influence of many factors and feedback process, they are best studies in terms of the co-evolution of knowledge, innovation, organisations, and institutions. *They stress the differences between systems, rather than the optimality of systems;* they make the differences between systems of innovation the main focus, rather than something to be abstracted away from. This means conducting comparisons between existing systems rather than between real systems and an ideal or optimal system. *They emphasise interdependence and non-linearity;* this is based on the understanding that firms almost never innovate in isolation but interact more or less closely with other organisations through complex relations that are often characterised by reciprocity and feedback mechanisms in several loops. This interaction occurs in the context of established institutions such as laws, rules, regulations, norms, and cultural habits. Innovations are not only determined by the elements of the systems, but also by the relations between them. *They encompass product technologies and organisational innovations;* this is based on the understanding that developing a differentiated concept of innovation -one that is not solely restricted to the conventional emphasis on process innovations of a technical nature-is necessary to comprehend the complex relations between growth, employment, and innovation. *They emphasise the central role of institutions;* they do so in order to understand the social patterning of innovative behaviour -its typically ' path-dependent' character -' and the role played by norms, rules, laws, etc. and by organisations.*They are still associated with conceptual diffuseness;* thus, further development will involve progressing from the present state of 'conceptual pluralism' to a clearer specification of core concepts and their precise content -a gradual selection process in which pluralism and ambiguity will be reduced by degrees. *They are conceptual frameworks rather than formal theories;* recognising that SI approaches are not yet that stage of development where they are capable of formal (abstract) theorising leads to an emphasis on empirically based 'appreciative' theorising. Such theorising is intended to capture processes of innovation, their determinants, and some of their consequences (e.g. productivity growth and employment) in a meaningful way.

As a result, systems of innovation as evolutionary systems in which institutions matter and learning processes are of central importance, has significant implications for the development of corporate strategies and public policies. In other words, it is not only related solely with the role of individual actors such as firms, universities, etc., but also with the interactions of those actors of innovations systems among the regional, national and global level. In particular, innovation system approaches provide for a much more careful and detailed development of public policies for innovation than do variants of the linear approach, which is discussed above. From system of innovation perspective, policy is partly a question of supporting interactions in a system that identify existing technical and economic opportunities or create new ones. Moreover, policymakers should develop selection criteria, such as the impacts on economic growth and employment, while supporting the creation of novelty. Thus, making these criteria explicit in terms of the economic and technical dimensions of innovation opportunities is main concern of the system of innovation approach.

4.2.1. National Innovation System

A number of definitions have been provided for the national innovation system by different theoreticians. Some outstanding approaches: "(T]he network of institutions in the public and private sectors, whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1991). "...the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge...and are either located within or rooted inside the borders of a nation state" (Lundvall, 1992). "...a set of institutions whose interactions determine the innovative performance ...of national firms" (Nelson, 1993). "...the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country" (Patel and Pavitt, 1994).

The definition of NIS features (SPO, 2001) are stated as; the capability of attaining new technologies regarding product or production methods; their adoption and utilisation; providing the diffusion of these new technologies to all activity areas of economy; being able to develop products and to design new products along with the design of new product, the capability to improve the production method and to design new methods; being able to design and produce the production (process) machinery required by the improved or newly discovered/invented production method; being able to maintain the technological research and development activity which supports the mentioned design and production processes; to develop the required technologies drawn from the scientific findings; and to produce the science that sets the source of those technologies; to ability to develop the organisation methods which regulate the relationships of research, development, design, production, and marketing processes both within themselves and among each other; and on higher levels, which reproduce once again those relations. Consequently, it is stated that NIS expresses the system of national institutions that possess these capabilities, and the relations among them.

Recent empirical evidence (Porter and Stern, 2002), also confirms a strong relationship at the country-level between the innovative performance and economic prosperity (measured in terms of GDP per capita). According to Niosi (2002), "...(the) concept of national system[s] of innovation is the key to explaining the behaviour and the performance of the set of institutions [and organisations], on which, long-term economic growth and sustainable development are based". Therefore, the ability of countries to develop, absorb, and diffuse new technologies relies on the organisation of national innovation systems.

In addition, the concept of national innovation systems should not be considered as the number of product or process innovations introduced in a specific space and time. On the contrary, national innovation systems need to be understood in a broader sense, which puts the real emphasis on the main determinants and the organisation of innovative action. Edquist (1997) states that national innovation system comprises "…all important economic, social, political, organisational, and other factors that influence the development, diffusion, and use of innovations." Hence, the NIS approach emphasises the crucial role of interactions among people, institutions, and firms in the innovation process. Innovations and technologies are the output of the system, which rise from the complex relations among the universities, public-private research institutions, other institutions, and firms. Actors and the linkages in the NIS are demonstrated in Figure 11. In addition, Porter (1990) articulates that:

> The principal economic goal of a nation is to produce a high and rising standard of living for its citizens. …the ability to do so depends on the productivity with which a nation's resources (labour and capital) are employed… Productivity is the prime determinant in the long run of a nation's standard of living, for it is the root cause of national per capita income. The productivity of human resources determines their wages, while the productivity with which capital is employed determines the return it earns for its holders…The only meaningful concept of competitiveness at the national level is national productivity…[A] nation's firms must relentlessly improve productivity in existing industries by raising product quality, adding desirable features, improving product technology, or boosting production efficiency…A nation's firms must also develop the capabilities required to compete in more and more sophisticated industry segments, where productivity is generally higher. At the same time, an upgrading economy is one, which has the capability of competing successfully in entirely new and sophisticated industries. Doing so absorbs human resources freed up in the process of improving productivity in existing fields.

In this context, Porter addresses the increase in innovation capability, in other words, he underlines that revolutionary new technologies -e.g. ICT- provide the opportunity for an era of innovation and improving productivity all industries so that improving of competition power of any country in the global area. On the other side, although the raise of economic globalisation links both the production and innovation systems of countries, globalisation does not provide the homogeneity of national innovation systems, as different countries have different experiences and institutional structures. Under these circumstances, the role of decision-makers is significantly important in the process of improving innovation performance, and consecutively, in increasing the competition capability. In this framework, the decisions, regarding particularly the improvement of networks of the system actors and innovative capacity of firms, become more remarkable and impressive (OECD, 1988). As recent NIS studies have revealed, there are some remarkable common points in science and technology systems of OECD countries that can be analysed under five basic aspects.

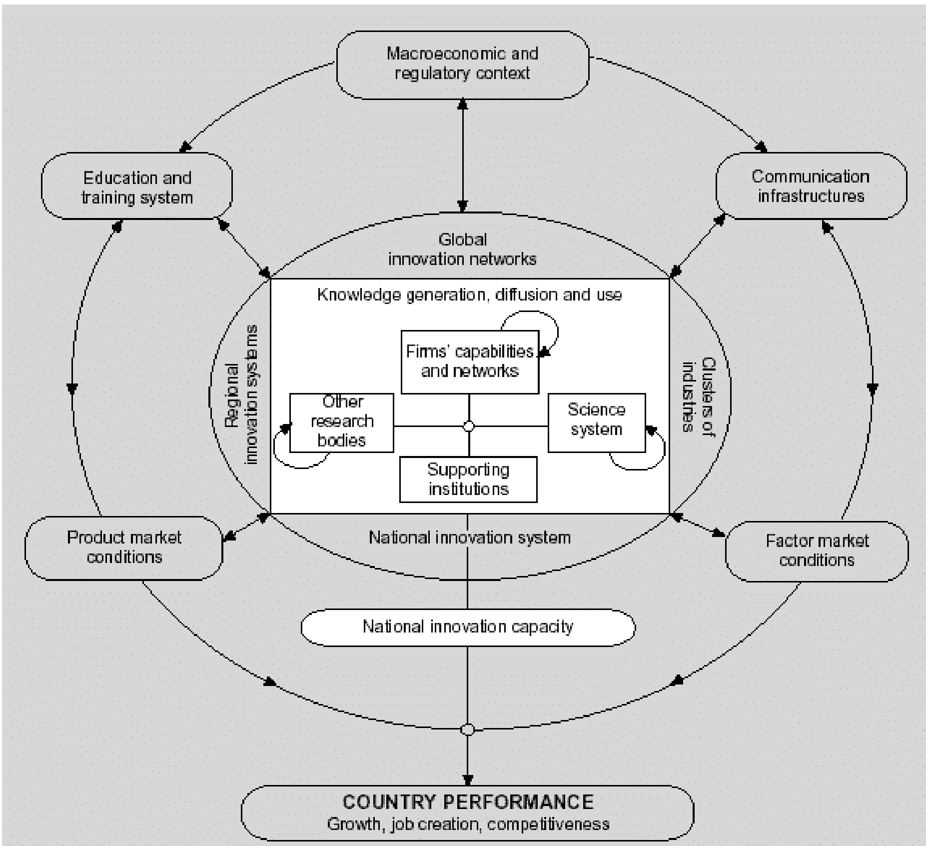

Figure 11 Actors and Linkages of NIS
Source OECD (1999)

The first aspect is that the *importance of science and technology* in national economies and global competition is fully realised by developed countries. Capability in technology and science is regarded as the basis of economic growth, sustainable development, and improvement of life quality. That is the reason for the measures that state takes in the area of science and technology in order to achieve scheduled national targets. These measures usually employ public resources for various determined purposes: creation of more effective and substantial brain power; improvement of national R&D capability; utilisation of this capability in preferred national economic activities targeting at its diffusion to the entire economic areas; implementation of mega-projects, which not only improve the technological capability of the nation, but also create new employment opportunities; and regulation of procurement policies, etc.

Second common aspect of these countries is the existence of a *central organisation or committee/commission*. The responsibility of this structure is to provide the participation of all actors, particularly universities and industries, in the policy-making process and to steer the co-operation and coordination among the actors. This structure operates either under relevant ministry/ministries or independently. It may be deduced from this condition that there is no rigid hierarchy in science and technology system; or the boundaries are not strict among the actors. On the one hand, while conducting their basic research studies, universities are linked to the system indirectly; on the other hand, due to their knowledge accumulation process, they are already linked to the system directly. As a result, strong interdependency among actors is the characteristic of science and technology system.

Efficient, effective, and strong *fund systems*, management mechanisms, and institutions constitute the third similarity among the developed countries. Although these mechanisms and institutions seem to be based on public funds, at the same time, they play the most efficient role in the process of national policy implementation. Although institutions handling the funds display structures that differ not only from one country to another, but also within the country itself, all R&D facilities in universities, institutions and private sector, directly or indirectly, are financed by public funds, either completely or partially, in all of these countries.

The fourth major common feature of these countries is that the *crucial role of public R&D institutions* that acquired in the determination of the country's capability in science and technology system, including some critical areas in S&T. While basic researches are conducted by universities, targeted basic researches or researches that would result in the middle or long-term are usually performed by public R&D institutions. Furthermore, many developments in advanced generic technology researches are implemented by public R&D institutions due to their cost, specific requirements, indeterminate results, etc. In addition, some types of researches on defence, nuclear power, space, ecology, etc. are carried out by public R&D institutions owing to their critical national importance and strategic consequences. Public R&D institutions also assist in the increase of national scientific and technological capacity, knowledge, and experience. Accumulated capacity, knowledge, and experience in public research institutions can also be used in economic activities by transfer mechanisms like patent. In short, the activities of public R&D institutions not only play a crucial role in the development of science and technology system of the country, but also orient the entire production system.

The last important common point is that in all the developed countries, their *science and technology management systems are the integral parts of their innovation management systems*. Science and technology system is the backbone of the national innovation system, but the innovation system, with respect to the social and institutional structure and labour process, is much more extensive and complex. Furthermore, unless the national innovation system has come to existence as a whole, the benefit created by the science and technology system will never be sufficient for any meaningful economic or social progress.

Final point of study on NIS is that the differences between the NIS of developed and developing countries. There are three major features that characterise the differences between the NIS of developed and developing countries, the coexistence of which in the science and technology system, that is, in the NIS of a country implies the classification of this country as a 'developing' country. First of these features is *the proportion of R&D* in total budget, which is usually less than 1 % in these countries. In general, R&D activities are financed and conducted by the states themselves. Therefore, these countries need to improve their science and technology infrastructure; which brings up the second feature, *the rate of innovation activities* that is usually realised in low levels in these countries and they are dependent on other countries in terms of technology. Finally, the NIS of such countries concentrates predominantly on *technology transfer* due to its essential character.

Furthermore, as we have already explained, the theory of 'catching-up' claims that developing countries can achieve growth more rapidly than the developed countries as they have the opportunity to obtain the technology base improved by the developed countries, unless there is a mismatch between the social capabilities and technological conditions (Abramowitz, 1990). Social capability of a country relies on a range of components, a couple of which, among all, play the crucial role: appropriate institutional structures and the capability of state in planning and implementing economic policies. Alternatively, technological conditions are rooted in the harmony of technological capability of society and appropriateness of the technology to the society.

An important difference between catching-up and other economies is the initial availability of a substantially larger stock of advanced technology to draw on. While catching-up economies may experience rapid economic growth and structural change for an extended period, their catch-up potential will eventually be exhausted. They will then need to expand their indigenous science and technology base.

Thus, in NIS, technological development is regarded as an iterative learning process, which is characterised by complex and interactive feedback mechanisms and relationships among actors in a specific national institutional context encompassing science, technology, production, policy, and demand. Therefore, NIS approach might be summarised by indicating two key-points of interest; the ways in which technological development is perceived, and the possibilities for government intervention. *Technological development* is acknowledged as a process of interactive learning; which includes not only R&D and knowledge production, but also the transfer, exchange, and use of knowledge and the demand for knowledge. *Government intervention,* likewise, maintains the institutional knowledge infrastructure of universities and research institutes; stimulates interactive learning among the variety of actors present in the NIS; monitors the NIS by institutional mapping in order to improve the system's overall performance; creates complementary links between public and private actors in order to optimise the use of the knowledge produced; creates and facilitates access to knowledge; and matches the supply and demand for knowledge within the system.

On the other side, determining which technologies are of strategic importance for a national economy and what knowledge infrastructure is needed to support the development and use of these technologies, however, is a very complex task because of intensifying global competition, rapid technological change, easier mobilisation of people etc. In addition, the vital question would be the ways in which funding decisions today should be effected by expectations of the future; a future acknowledged as uncertain and yet 'creatable'. Numerous questions follow this argument: what role should national policy play so as to co-ordinate organisations? How can some sense of direction and priority be given to research agendas in conditions of uncertainty? When does the need to make decisions today foreclose future alternatives? Who should be involved in the attempts to derive future scenarios? etc.

Therefore, recognising the identification of such areas involves difficult matters of judgement; accordingly, it was argued that a framework was needed to draw together various knowledge inputs, establish communication between science and industry, and mobilise resources according to the development of strategic objectives. Thus, effective interaction between the scientific community and industry was considered of vital importance in the formation of commercial and academic strategies to promote innovation, to the creation of lasting networks between industry, government and the science and technology community; and to the emergence of coherent visions within their communities on complementary developments in science and technology.

Moreover, in industrial economics and especially in knowledge-based economics, recent works show the effects of path-dependency, irreversibility and lock-in on the diffusion and creation of innovation processes, which are able to stop the development of a technology or to lock the economic system in some sub-optimal choice. Therefore, industrial policies have a major role in selecting and supporting the innovative process. Nevertheless, to select the appropriate policy is not easy in dynamical and complex social systems. In fact, the question is to know what kind of small events in today's decisions may have great importance on tomorrow's actions, and what kind of events will have no impact. Thus, to be able to forecast the development of knowledge and technological change in some well-known trajectories could be one of the major tasks of industrial policies. Therefore, it is not surprising that recent years have brought a significant revival of public foresight activities in many countries.

Foresight programmes reflect an increasing concern with matters of co-ordination, creating and supporting the technology support systems of particular groups of firms, those formal and informal institutions that interact in specific areas for the purpose of generating, diffusing, and utilising technology. In other words, to overcome these issues, a number of governments carry out foresight studies to identify technologies that might be expected to make important contributions to economic growth and other national goals in the future. Finally, the sequence of emerging innovations and the successful firms are the outcomes of the process and are not a specific concern of the policy maker. Winners emerge, they are not pre-chosen. All these are entirely consistent with the evolutionary perspective. Government can neither predict which are the likely innovations or the promising markets. Rather, its proper role is to build an infrastructure in support of firms and let the innovations follow from the market process.

4.3. Foresight

As we have already explained, today, the architecture for understanding the impacts of a modern science and technology policy portfolio is more complicated than it ever was. The interwoven nature of various types of policies and trade-offs any policy portfolio requires touches on different aspects of the entire quality of life issue. The challenges for a particular policy in the arena of S&T originate from increasing environmental, economic, and social problems. The aim of those policies is to make the (national, company) innovation system adaptive enough to meet those challenges. Additionally, there is an actual increase as well-known in the interdisciplinary and trans-disciplinary sub-fields in the area of S&T. Basic or even fundamental research moves towards closer contact with industrial research and development, and science-based technology is pervasive in many industries, which is observed in a number of areas, such as: (a) In politics, there is an increase in the number of actors and interventions. National policies in some countries are pressured by supranational as well as local and regional bodies. (b) In business, but not in government, globalisation is taking place. For both sectors, and in particular their science establishments, public and private finance is being squeezed, (c) R&D budgets are limited; the reduction of R&D budgets is made easier by the fact that the impact is not apparent in the short term. Capitalism is inherently myopic and it favours near-term investments and resists long-term ones such as infrastructure, education, R&D, military. These are left to government and it is no accident that it was the U.S. military and its associated aerospace industry, which took the lead in promoting the development of diverse forecasting tools. The reason is readily apparent: in the four decades since World War II (not considering the last decade) the military confronted the combination of rapidly changing technology, long system lead times, and a perceived long-term Cold War threat.

In short, technology forecasting first came to prominence in the late 1950s in the United States defence sector and in work by consultants, e.g. the Rand Corporation. The latter were responsible for developing some of the principal tools of technology forecasting, such as the Delphi questionnaire survey, which is developed by Helmer and colleagues. Large-scale forecasting exercises were carried out during the 1960s by the US Navy and by the US Air Force. Technology forecasting was also taken up by private companies, for instance, in the energy sector. However, the next developments, and the emergence of what is understood with the term 'foresight' today, took place in Japan. In the last century, most societies have come to accept the need for a long-term perspective. National foresight studies have been the key social innovation to satisfy this need. Started off as 'science and technology' foresight in Japan in early 1970's, this first generation foresight had been replicated and further developed by European countries as a notion of 'foresight' covering all areas including society and culture in 1990's. This led to the foresight programmes in UK, Germany, Netherlands, Finland, Ireland, South Korea, France, New Zealand, etc. What does 'foresight' really mean? 'Foresight' is an elusive term having different meanings to different people. Slaughter (1995) presents a comprehensive study of the foresight principle. He considers that:

> Foresight is not the ability to predict the future…It is a human attribute that allows us to weigh up pros and cons, to evaluate different courses of action and to invest possible futures on every level with enough reality and meaning to use them as decision making aids…The simplest possible definition [of foresight] is: opening to the future with every means at our disposal, developing views of future options, and then choosing between them.

According to Slaughter (1995), foresight is an attribute, or a competence; it is a process that attempts to broaden the boundaries of perception in four ways; by assessing the implications of present actions, decisions, etc. (consequent assessment); by detecting and avoiding problems before they occur (early warning and guidance); by considering the present implications of possible future events (pro-active strategy formulation); by envisioning aspects of desired futures. Furthermore, Horton (1999) discusses the elements that should constitute a successful foresight process. Successful foresight, she argues entails three consecutive phases:

> Phase one comprises the collection, collation and summarisation of available information…and results in the production of foresight knowledge. Phase two comprises the translation and interpretation of this knowledge to produce an understanding of its implications for the future from the specific point of view of a particular organisation. Phase three comprises the assimilation and evaluation of this understanding to produce a commitment to action in a particular organisation.

Finally, Irvine and Martin (1984), to the best of our knowledge, coined the term foresight in the early 1980s and pointed to the communication or procedural power of it. The term foresight is used in the sense of outlook. This is not the same connotation as a prediction, which would be closer to forecast. Foresight is equivalent to a bundle of systematic efforts to look ahead and to choose more effectively. Thereby, foresight takes into account that there is not a single future. Depending on action or non-action at present, many futures are possible to occur, but only one of them will happen. To select a desirable future and to facilitate its realisation is one of the aims of technology policy. Foresight is:

> …[The] process involved in systematically attempting to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits (Martin, 1995).

The relation of foresight to planning has been pondered by Coates (1985). According to this source, foresight is defined as "a process by which one comes to a fuller understanding of the forces shaping the long-term future which should be taken into account in policy formulation, planning and decision-making…Foresight is, therefore, closely tied to planning. It is not planning - merely a step in planning." In addition to the fact that a foresight process should strive to be systematic and comprehensive, it must be able to accommodate a wide range of information, must be public, and avoid prediction. It is a political question whether government bodies would like to give more emphasis to direct intervention in research matters (e.g., by financing specific R&D projects in industry) or to more indirect support (e.g., tax reductions for R&D projects or subsidies to those companies hiring new scientific and technical staff). Therefore, six important aspects of foresight can be stated. *Firstly*, foresight is not a technique (or even a set of techniques) but a process that, if well designed, brings together key participants from different stakeholder groups (the scientific community, government, industry, NGOs and other public interest or consumer groups) to discuss what sort of world they would like to create in coming decades. *Second*, the attempts to look into the future must be systematic in order to be called under the heading of 'foresight'. *Third*, those attempts must be concerned with the longer-term; by which it is meant a typical horizon of ten or more years, generally ranging between 5 to 30 years. *Fourth*, successful foresight involves balancing science or technology 'push' with market 'pull'; as it identifies possible demands related with economy and society, as well as potential scientific and technological opportunities. *Fifth*, the focus should be on the prompt identification of emerging generic technologies, in other words, technologies that are still at a pre-competitive stage in their development and where there is consequently a legitimate case for government funding. Finally, *sixth*, attention must not only be given to the likely social benefits or adverse consequences of new technologies (e.g., the impact on the environment), but also to their impact on industry and the economy. As a result, foresight, as a means of analysing plausible long-term perspectives for societal and technological developments, has recently gained widespread use in generating inputs to national policy debates.

4.3.1. Methods Used in Foresight Programs

Sceptics argue that adequate strategy and policy planning methods and processes are already well established at all levels of public and private decision-making. However, the rules of the game are changing radically, eroding the value of more rational planning and linear methods of policy development, accentuating the need for more real-time interactive methods which foresight typifies. The characteristics which newly emerging forward-planning foresight-type practices demonstrate (Figure 12), is the dominance of interactive and participative methods of exploratory analysis and study in what could be termed a 'new paradigm'. The methods are not 'new' in the strictest sense, as they have been practised and developed over several decades. Nor do they replace more traditional forms of planning or serious scholarly studies in the desktop and field research mode. However, their use is becoming more and more extensive and they increasingly constitute a decisive element within a planning exercise. What seems to be determinant in this trend is the fact that accelerated rates of change in society, markets, technology, and science have over-stretched rational planning approaches the utility of which depends on long periods of relative stability. What foresight methods impart is a much more 'emergent' planning approach, which functions in a more real-time way. In the following pages, I limit myself to a brief review of the foresight methods e.g. Delphi, expert panels, S.W.O.T etc. and for this purpose, the methods that have been mainly used in foresight activity are analysed below.

Brainstorming

As this process is self-explanatory and widely used, it does not need a complicated explanation. It is a group method, where a period of freethinking is used to articulate ideas. In the initial phase, which is conducted under the pressure of restricted time, ideas are simply recorded verbatim and validity testing is not permitted. In the second phase, the duplicate ideas are eliminated and synergistic ones are amalgamated as the idea testing proceeds. At the end of the session, the group has produced a set of ideas that have been tested in an ad hoc fashion and are approved for further and deeper evaluation for feasibility and relevance to the situation. In the early stages of formulating questions that need discussion or on which opinions needs to be sought, brainstorming can be a useful technique for expert committees and for a consultation management group (TÜBİTAK, 2001).

The Delphi Method

Linstone and Turoff (1975) defined Delphi as "a method for structuring a group communication problem". The Delphi method consists of experts' judgement by means of successive iterations of a given questionnaire, to show convergence of opinions and to identify dissent or non-convergence. Each one of the iterations constitutes a 'round' and the questionnaire is the medium for the experts to interact. The Delphi method is considered useful especially for long-range aspects (20 to 30 years), as expert opinions are the only source of information available.

The main advantage of this method is that panel members can shift position without losing face if they see convincing reasons for doing so. The panel members will usually have widely varying estimates on each topic in the beginning of the process and do not always shift the opinion under the influence of the assessments given to them by the other panellists. Therefore, it is important to continue until there is stability, that is, until there is not much change between rounds (Linstone and Turoff, 1975). This characteristic differentiates

Planning: A rational process of decision-making and control focused on the allocation of resources with respect to fixed objectives.
Strategic Planning: A process of managing organisational change focused on the development of an organisation and of its human resources, structures and systems, taking account of and combining top-down and bottom-up emphases.
Forward Planning: This denotes the process of exploring the future in all its possible dimensions, with the help of probable scenarios, by including analysis of the socio-economic impact of firm decisions and objectives, and defining key elements likely to give rise to sudden deviations or changes in trends. Unlike planning, this approach is directed much more towards strategic questions than towards operational problems.
Foresight: Foresight has the same orientation with forward planning. It employs the above-mentioned scenario analysis and many other exploratory methods to produce insights to the challenges implied by prospective technological, economic, and societal developments. But it is also highly participative seeking to stimulate networking among key actors (i.e., policy-makers, researchers, enterprises, not excluding the general public) and endeavours to translate prospective analysis into impacts and implications for present-day decisions - i.e. it generally contains a more-or-less explicit feedback into 'planning' and 'strategic planning'.

Figure 12 Planning, Strategic Planning, Forward Planning and Foresight

Delphi from a committee: a committee usually seeks consensus. Delphi may, and does, exhibit bipolar views and does not force consensus. However, the number of rounds must be limited because of dropping interest -panel attrition- (TÜBİTAK, 2001). It is assumed that the method makes better use of group interaction. If a single expert's opinion is at variance with the group -cognitive dissonance-, this may stimulate cognitive processes, which might bring information to consciousness, which is not available otherwise (Rowe, Wright, and Bogler, 1991). This process of reiterated, reinforced cognitive inputs continues until there is stability. The main challenge for the Delphi, which is also a cognitive problem, is the generation of topics. Either, they originate from elsewhere, like committees, instead of panellists, and then we are again confronted with the consensus trap of the scientific or technological establishment. Nevertheless, Delphi need not begin with issues generated elsewhere. The main initial Delphi work was performed at the RAND Corporation, Santa Monica, after 1948 (Figure13). Forecasting, as it was known then, was motivated by Bush's book *Science, The Endless Frontier*, advocating the transformation of U.S. military economy R&D during WW II (e.g. the Manhattan Project), into long-term civil research and commercial exploitation. The earlier attempts were also spurred by the scientific successes of the Soviet planned economy (e.g. the hydrogen bomb and the launch of the Sputnik). Finally, the Delphi method remains a flexible tool and most of its shortcomings can be mitigated. However, it must be remembered that the Delphi method is not science and expectations tempered by any contrary view will be mistaken (TÜBİTAK, 2001).

Scenarios Writing

The use of scenarios has become more popular because it claims (a) to encompass the complexity of the real world and (b) enable alternative visions of the future to be presented in the form of a logical sequence of events. Given these purposes, the use of scenarios has become popular at times when extrapolation of the present into the future, on the assumption that tomorrow will be just like today, has ceased to lead to sensible and robust decisions. When events seem to contain a mix up of apparently unrelated information, scenario writing can provide a basis for organising information and future possibilities into alternative visions for the future that can be comprehended (TÜBİTAK, 2001).

Cross-Impact Simulation Models

All cross-impact models rely upon informed judgement and opinion; they are most suited to deriving a qualitative understanding of the structure and form of a situation rather than its precise detail. Several cross-impact models exist; all of which stem from technological forecasting. The most suited to foresight programmes is the modelling process developed by Kane and called KSIM (Kane, 1972). KSIM is a group study, typically run as a workshop that can be used to illustrate the ways of interactions, which influence qualitatively the behaviour of complicated systems (TÜBİTAK, 2001).

Relevance Trees

The method had been derived initially from decision analysis in the form of decision trees. However, a relevance tree reverses the shape of a decision tree since it is a normative process that sets out to define the route to a defined end, the tree taking a probabilistic form. The hierarchical shape of the tree exhibits the dependence of the technology at one level to those at the adjacent levels. However, interdependence of topics, which is an important aspect of technological development and hence of foresight, is not a point emphasised strongly enough in relevance trees. (TÜBİTAK, 2001)

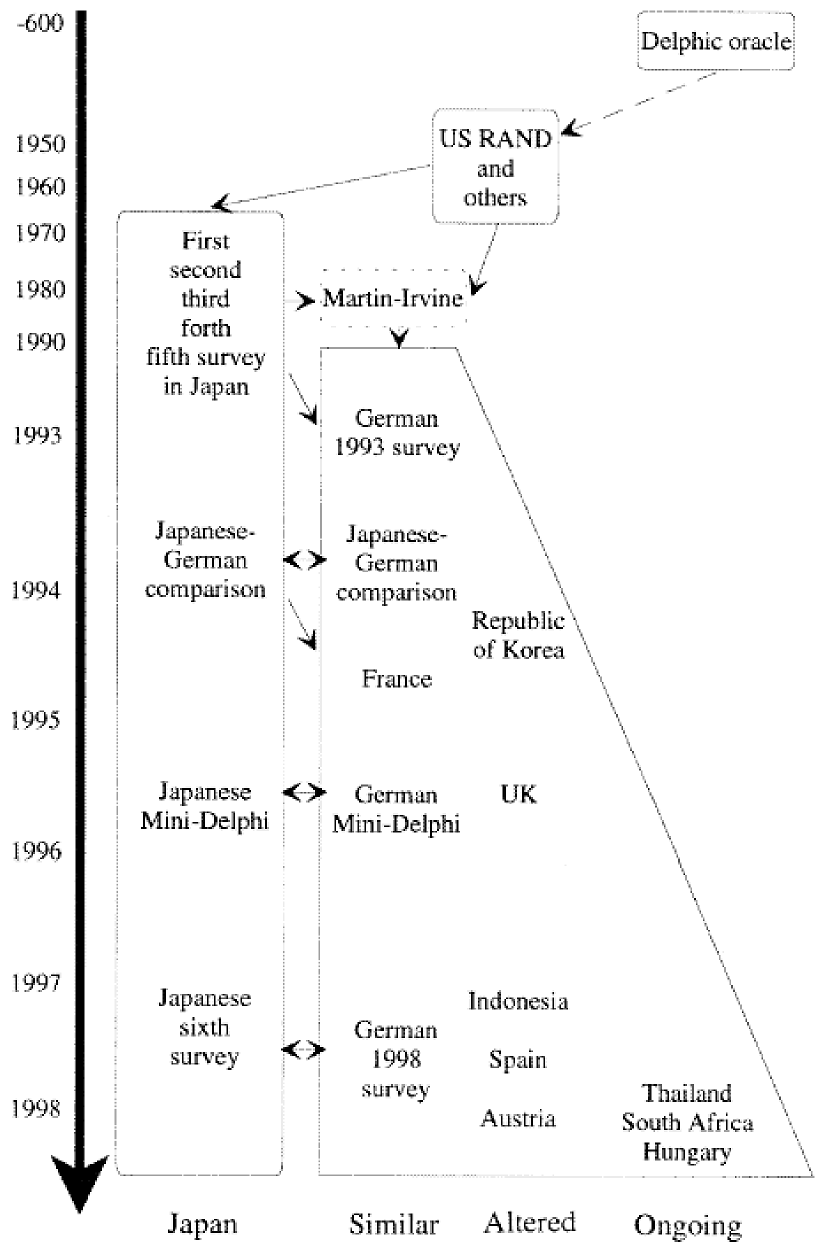

Figure 13 Career of Delphi Methods
Source Hariolf and Harold (1998)

SWOT (Strengths, Weaknesses, Opportunities and Threats)

SWOT analyses are methods that assist in the determination of the strategic aims of companies or countries. The basis of SWOT lies in the in-depth analysis of a country's or institution's strengths, weaknesses, opportunities, and threats within the context of a certain technological area or capability, in both their own and external viewpoints. The strengths and weaknesses are related to the inner dynamics of the country (or institution). On the other hand, opportunities denote the situations external to the country or institution, which could improve performance when appropriately utilised. Lastly, threats are the external situations or powers that could destroy the performance when required prevention measures are not taken (TÜBİTAK, 2001).

Expert Panel

Utilisation of the expert panels to deliver opinion on a certain subject is the most frequently used method in the foresight studies worldwide. As the discussion of conflicting viewpoints has a vital role in the foresight studies, representation of different viewpoints should be provided in panels. As the topics to be included in the study of national innovation systems would be vast, it is not possible to handle all of them within a single panel. Therefore, a hierarchical structure is formed including a series of workshop sub-groups under an executive committee. Based on the topics agreed in the foresight programme to be discussed upon, each of the workshop groups and sub-groups conduct their studies in the science & technology and/or industrial & trade sectors, sometimes by consulting to the external experts when required for a specific related to their topic. The executive committee on the other hand, organises the coordination of workshop groups and integration of the reports. In general, the expert panel method has its advantages in revealing the benefits of the foresight process (TÜBİTAK, 2001).

4.3.2. Reasons of Foresight

As a result of economic liberalisation in China, industrialisation in East Asia, and the political changes in Central and Eastern Europe, the number of 'players' in market economies has dramatically increased in recent years. One consequence has been an escalation in industrial and economic competition. Definitely, this proceeding increased the competition between countries as much as among companies. At the same time, however, labour costs are still unbalanced; and thus, where companies find lower costs or other advantages, they easily transfer their financial resources and shift their production. For the richer and more industrialised countries, focusing on science, technology, and innovation is one way of maintaining competitive advantages. However, there is a widespread recognition that market is a rather short-sighted, risky, and unpredictable area for companies to conduct long-term researches. This fact emphasises the necessity that governments must assume, at least some part of the financial costs of long-term researches; however, this does not mean they should fund all. The selection of the projects to be funded should be done according to a set of criteria, which can be offered by technology foresight as a process to help make those choices. This, in turn, means that technology and science are assuming ever greater importance. In other words, this support for science and technology spending is now largely couched in terms of national economic competitiveness. In fact these competitive pressures are not only severe in developed countries but also developing countries (e.g. Turkey), as they are situated so close to a number of rapidly growing economies with substantially lower labour costs. Moreover, there is mounting anxiety about the relation between economic competitiveness and a number of social factors such as decreasing job areas, which do not require science and technology knowledge, in other words, increasing unemployment, deteriorating working conditions, environment, social exclusion/cohesion etc. As a result, national science and technology policies must be balanced to confront such social risks, like unemployment, inequality, etc., and in order to achieve these goals, new policy tools as technological foresight should be utilised.

Besides globalisation and growing economic competition, a second major 'driving force' is the increasing pressure on government spending. It is for sure that governments have to balance their budgets between expenses and revenues in line with their prospects. Yet they are under several pressures resulting from demography and ageing population together with the rising expectations concerning social healthcare, education, and social welfare services. In an example, in EU, on the one hand, they have to meet the criteria which they have targeted, on the other hand, considerable concerns have been expressed regarding the future viability of the 'European Social Model' in the context of increasing globalisation. The essence of these arguments is that Europe can no longer afford to maintain the present welfare state arrangements as they act as a drag upon the global competitiveness of Europe' s economy (EC, 1993). The outcome of this has been a growing consensus that the welfare state must be reformed and costs must be reduced. Another way to achieve balanced budget is politically acceptable limits to tax-raising, however, if a government attempts to extract taxes above a certain level, companies or more affluent individuals may take their business 'off-shore' to a country where the tax system is not so burdensome, something which has been made much easier by new technology and the growing use of electronic transactions. Thus, governments have to be more careful in their spending. These constrains on public spending will result in growing demands for better value for money from all areas of government spending. To manage these expectations, they have to obtain new policy tools, along with a better justification for government funding of research and technology. As a result, no longer can any country afford to try to do everything in science and technology. Choices have to be made. This is especially true for smaller economies like Turkey. Hence, what is needed is a mechanism for making choices between competing alternatives in science and technology, and for linking science and technology more closely to the nation's economic and social needs, while recognising that future developments cannot be simply programmed from the present. Technology foresight offers such a mechanism.

Complexity is forced by interactions of systems of a variety of forms, including interactions among local, regional, national and global systems; which are the results of both research & technology policies, and economic, political, social policies, in relation with public and private sectors; e.g. healthcare, post/mail service; different technology systems; and different producers of knowledge, etc. Gibbons et al. (1994) have argued that the knowledge production process is characterised by growing trans-disciplinarity and heterogeneity (in terms of producers of knowledge) with more of it being carried out in the context of application. As we have already underlined, those major innovations often occur when previously separate streams of technology flow together or fuse.

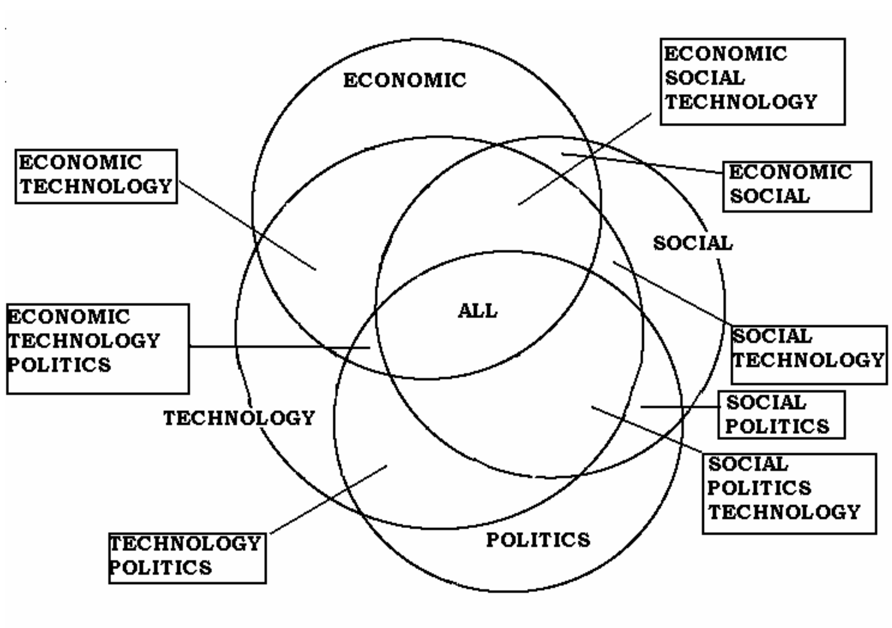

Figure 14 Foresight Process intersecting with the Social, Technological, Economic and Political Spheres

Therefore, new type of policies are needed due to the growing interactions between systems of different forms for a better understanding of the complexity of system; flexible policies, response and systems; policy tools linking different partners and their needs, values and so on; a clear division of responsibility between national, regional and global bodies and their respective policies; increased and more effective networks, partnerships and collaboration. Thus, all these necessities and/or obligations are provided by technology foresight in a systematic, open, and collaborative manner.

In summary, as in Figure 14, foresight opens up the possibility of negotiating a new and more fruitful relationship or "social contract" between science and technology, on the one hand, and society on the other (Martin, 1997). These process benefits are encapsulated with 5Cs identified previously by Irvine and Martin (1984):

- Foresight has enhanced Communication (among companies and also among researchers within themselves, and among researchers, users, and founders)
- It has resulted in greater Concentration on the longer-term future
- It has provided a means of Coordination (again among researchers and between researchers, users, and founders)
- It has helped create a level of Consensus on desirable futures over the next 10–20 years
- It has generated Commitment to turning the ideas emerging from the foresight programme into action.

4.4. Turkey

The main approaches adopted after 1960 in order to overcome the economic and political crisis have been 'planned development' in economics, and a more democratic atmosphere in politics. In the 1960s, the local production of basic consumption goods was generated in industrialisation. The agenda has been to verify the secondary phase of the industrialisation, supported by the local production, and to obtain the production of the durable consumption goods in Turkey, such as automobile, refrigerator, washing machine, and receiver. At the outset, private capital, importing these products from abroad has been assigned to this function. The private commercial capital, which conjoins foreign capital and SME services, is directed towards industrial production in an atmosphere in which it is protected against external competition. In the process of the industrialisation, the function of SME has been to undertake the production of interval goods like petroleum-chemistry, aluminium, iron-steel by benefiting from the foreign loans. In the 1960s, when the union rights have been put into effect, despite the rapid growth in economy, both internal and external factors brought to the agenda the well-known dilemma of democracy versus economic development and in 1971, the gained rights and freedom have been restricted with a new military intervention.

The aspiration for rapid industrialisation, which symbolises the economic policy of Turkey, acquired a new characteristic in 1970s. In early 1970s, full membership to the Customs Union has been a key purpose, which Turkey applied for at the end of 1950s and obtained a partner membership status in 1963. The strategy that is defined as import substitution industrialisation and on a large-scale marked the period between 1960-1980, made positive contributions to the establishment of the local industry. Over-valued exchange rate has provided intermediate goods and investment goods, without limiting imports, to be sold inexpensively to the industry; while negative real interest rates created opportunities for inexpensive loans. Due to the over–valued exchange rate policies, as all these factors throughout the period coincided with resource transfer to the industry from the agricultural sector, the only export sector, and with the domestic demand, which increased with the public expenses, very convenient conditions have occurred for both investment and production.

Thus, human resource with a rather important investment capacity and industrialisation consciousness/culture has occurred throughout this period. However, either in terms of productivity and cost, or in terms of quality and product variety, having been established with extreme and continuous protection, industry had a very little power for international competition. When evaluated in terms of production opportunities, the structure of the industry, which was accustomed to gain practically high profits, as devoted to domestic demand and with protection measures, has started to be one of the major problems of Turkey. However, another point to be remembered is that the major foreign deficits appear in an atmosphere in which they can be financed easily by foreign countries and organisations throughout this industrialisation process. This provides Turkey, like other developing countries, with the opportunities for the required industrialisation import without feeling anxious about exports.

This situation has made import substitution industrialisation extremely sensitive to external factors. In fact, due to several internal and external factors, it experienced a severe crisis in the middle of the 1970s. The major external factor is the worldwide crisis in the economic structure that occurred due to the devastation of

US economic structure, the dominant economy since WW II, and the related worldwide changes in all institutional structures ranging from international monetary system to international financial institutions. Under these circumstances, the countries with which Turkey had intense economic relations faced a severe crisis that led to stagnation, inflation, and unemployment. Moreover, the rapid increase in the crude oil price, announced by OPEC in 1974, and the arising Cyprus problem, together with all these external factors, has prevented Turkey from industrialisation by having continuous foreign deficits. Despite the economic crisis resulted by external factors, in the 1970s economic activity and productivity could not become dominant ideas in Turkey. Used to work with high profits and absolute protection, the industry had an important role for this lacking situation. The short-term rent view, which always substituted the economic rationalism in Turkey, became absolutely intense towards the end of 1970s. In addition, IMF stability proposals have not been sufficient and the external payment difficulties that took place together with the solid political crisis and inflation have resulted in the 1980 coup d'état.

The First Five-Year Development Plan (1963-1967)

Although advanced technology use, research, and technical development notions were emphasised in the first plan, it is hard to state that there were proper implementations of technology transfer and education policies and R&D activities. TÜBİTAK was established in this term. (DPT, 1962)

> Scientific and Technical Research Council will be established for the purpose of organising, coordinating, and promoting basic and applied research. Scientific and Technical Research Council will help in directing the research activities to the targets of the plan and settling the research priorities accordingly (SPO, 1962).

The Second Five-Year Development Plan (1968-1972)

Science and research topic was taken as a separate section in the plan, however, the focus of this topic was too far from analysing the technology development, industrialisation and developments in industrial sectors, in other words, it was not more than a generic conceptualisation. That is why, not only in the decision-making process but also in practice level; the required studies could not be realised in R&D activities (SPO, 1967).

The Third Five-Year Development Plan (1973-1977)

The general and current conditions of technology policies were elucidated in the plan. At the same time, the vital role of advanced technologies for the realisation of the industrialisation aim had been emphasised. The general principles of technology transfer were much more emphasised in this plan compared to the previous plans: "integration of the technology policy with the industry, employment, and investment policies and enhancing the technological abilities of certain industrial sectors" (SPO, 1972). In addition, the plan emphasised two main deficiencies regarding technology policies in Turkey; first, the absence of an institutional mechanism, which provide maintenance of technology transfer and creation of links between technological inventions and industry; and second, lack of infrastructure, which provide production of technology in a country (SPO, 1972).

The Fourth Five-Year Development Plan (1979-1983)

The insufficiency of resources for R&D activities, the lack of organic links between R&D institutions and industries, non-establishment of national knowledge flow system, insufficient capability of technology assimilation, and the high cost of technology transfer were underscored in the plan.

> At the beginning of 1980's, 'Turkish Science Policy: 1983-2003' was prepared… under the coordination of … Minister of State. This was the first time that a detailed science and technology policy document had been tried to be prepared. In this document, technology had also been considered as a basic motif and priority areas of technology had been put forward. This new approach has necessitated the establishment of a new institution: The Supreme Council for Science and Technology (SCST), which enabled the design of science and technology policies with the participation of ministers, high-level bureaucrats and representatives of non-governmental organisations, who take part in economy management and arrangement of the main fields of activity in social life. However, 'Turkish Science Policy: 1983-2003' could not have been implemented (TÜBİTAK, 1999).

In addition, some emphasis have been put on related areas such as; development of R&D activities concerning industrial needs and reinforcement of their relations; more investments in R&D activities, reestablishment of technology policies that would include preferential technology production and transfer regarding sectoral needs. Furthermore, acceptance of the legislation on industrial ownership rights, rearrangement of regulations for the aim of increasing quality control techniques, and development of special employment programs, which were based on labour-intensive technologies and implemented in rural areas, were put into the agenda of the plan.

The period after the coup d' état should be evaluated as the years of important developments in terms of stabilisation in both external balance and public finance and monetary market, as the years of the fundamental changes. However, when these years are scrutinised more closely, it cannot be denied that these measures have some features that could lead to instability in economy again.

Moreover, the entire manufacturing industry, which provided exportation after 1980, was comprised of textiles -ready-made clothing, iron-steel, food, that were founded before 1980 and based on production capacities, and to a certain extent durable goods. After eight years, there was no change yet in this composition. Exports could be increased more by utilising the capacities effectively and decreasing the domestic demand, rather than by generating production and new capacities. It is unavoidable to face serious problems in carrying on the increase in exportation that have such kind of properties, in other words, that is provided by short-term measures. Such problems have started to be experienced in 1988 when the impetus of the increase in exports has begun to slow down. For instance, enough importance has not been put on the verification of the goods in exportation, and on the increase in production and capacity, which would provide opportunities for the new sectors to extend towards exportation, hence devaluations have started to loose their increasing effects on exportation in the same sectors with the same effectiveness. In other words, Turkey has come to the end in the increase by continuously keeping the amount of the exported goods and the prices low.

On the other hand, the financial supports did not have effects such as decreasing the cost prices and providing an internationally structured competition (power), since these financial supports were effective in decreasing artificially the price of the exportation, rather than decreasing the costs. It is well-known that the positive effect of the increase in exports, which was applied particularly after 1980 and which has become intense among the big foreign trading firms that have attained a particular exporting capacity, were not reflected on the producer. Owing to this reason, an important structural change in exporting sectors, technological modernisation, and competition power based on the increase in the quality and productivity could not be developed. In point of fact, as there was a profusion of financial supports resulting especially from the international treaties, there has been an indispensable hesitation in the impetus of the increase in exportation.

Throughout this phase, the increase in the interest rate of loans has been a decreasing factor on the investments. This has also affected the country's production negatively and thus, despite the emergence of new technologies, labour-intensive production methods have been encouraged. The bank capital, which eluded from production due to high interest rates, has inclined towards essentially high consumer demands, which was a situation inciting inflation and importation. In monetary market, improvement, particularly in the production possibilities of the country is observed in the dispersion of the loans. The portion of productive sectors especially the portion of the manufacturing industry, has gradually declined. Consecutively, a wide spread dispersion of the new financial tools including the stock-exchange/bourse did occur. It is unavoidable that retiring from the goods and service production, the monetary capital would incline towards its own cycle with a gradually increasing proportion, resulting in an increase in prices. In fact, Turkey's economy in the 1980s experienced inflation, as it was also one of the major problems before 1980; however, this time it acquired continual / persistent characteristics with a higher rate. In short, we can say that the applied economy policy has been defeated by the inflation. Another dimension of the commercial and financial freedom started from 1980 has been the convertibility of Turkish lira, with which, an international financial freedom period, enabling firms and organisations to familiarise with foreign exchange has started.

Financial liberalisation together with the unbalance between exchange rate and country realities has reduced the effectiveness of the applied foreign-oriented policy. At the national level, the economic policies lost their effectiveness, leading to serious economic problems in countries like Turkey, where productive capacities could not be reinforced for years; the sectors that are opened to the international competition has not been increased and verified; and the labour productivity has been low. In addition, the rise of the interests had rather negative effects on the production opportunities of the country. Firstly, avoidance from new stable capital investments led to the lacking pursues of new technologies. Thus, the increase in the power of the international competition was only experienced in the sectors that utilise inexpensive labour for production. The most evident instability in real sector has occurred in the impetus of the GNP development since 1980. A stable period follows almost every rapid development period. This kind of instability indicates that the structural transformation still faces difficulties, the most evident of which is the difficulties taking place in real sector and investment.

On the other hand, the increase in the exports after 1980 has brought a change in the export composition. The 80% of the total exports consist of the exportation of the manufacturing industry, and the rest is shared by the agricultural and mine sectors. Private sector has invested in these three commercial sectors, however in a declining trend after 1980 and they have started to move towards sectors like finance, real estate, etc., which are not commercial. This change in the distribution of investments is contrary to the expectations that resulted from the foreign-oriented policies that have been under effect since 1980, as the expectation was to have a development in exports by focusing on the investments in the commercial sectors. However, with the foreign-oriented policies, there has been a decrease in the profit expectations in foreign-oriented sectors more than the domestic-oriented sectors and the investments have started to be exhausted by focusing on the domestic-oriented sectors that are not commercial.

As in the most of the developing countries, mark-up is common in Turkey as well, which denotes the reflecting the costs to the prices by adding a definite profit margin. In the manufacturing industry of Turkey, the imported input and prices constitute the basic input costs and the costs of the imported inputs are above the prices. While the costs of the imported inputs that have increased as a result of the high 1980-88 devaluations are compensated with low prices in the manufacturing industry of Turkey, the prices that increased after 1989, are compensated with the decreased input costs, due to the valuation of Turkish Lira. Thus, during the term between 1980-90, there has been a fairly stable, even increasing profitability in the manufacturing industry. However, this profitability does not turn into investments in the industry, in other words, a profitability that does not turn into the investments took place in the manufacturing industry in Turkey.

The most evident reason for this development is that there is not a high profitability rate in financial sectors, more generally, in the sectors that are not commercial. After 1990, the most important factor that constituted profitability in the manufacturing industry has been financial profits. The rapid development in the financial sector and the extraordinary rise of the interest rates caused the income, obtained from real sector to be used in financial sector. During this phase, the rate of the disposable profit with the financial profits resulted in an increase in 500 big industrial companies. The development of the financial sector should be more than its own purpose, it should be constructed in order to develop the production opportunities and investment capacities, and provide enduring real sector balances.

In the second half of 1993, on account of the instabilities and developments in both public domain and external economic relations and monetary market, there has been a need for new policies in economy. This demand for new policies, which aim at keeping the interest rates low in order to struggle with inflation and to reduce the burden of the public loans, has resulted with a rapid increase in the demand for foreign exchange. This process has given rise to the crisis that is resulted from the economic instability, at the beginning of 1994, leading to a severe crisis, which seriously stroke the long-term economic development, and the infamous '5 April' decisions, as a consequence. Moreover, the effects of the 5 April decisions have been very limited on balance of payments, exchange rate, public payment balance, and interest rate.

The Fifth Five-Year Development Plan (1985-1989)

It was explicated in this plan that the structure of the pursued industrial policies during the planning term were mainly founded on importing without scientific and technological investigation. Moreover, it was emphasised that industries prefer ready-pack technology transfer, rather than scientific and technological research in the country, so this process resulted in a more dependent industry (SPO, 1984). For the purpose of finding solutions to economic and industrial problems via R&D activities, the targeted sectors, sub-sectors, and areas were pointed out (Yücel, 1997). Therefore, in order to remove the infrastructural deficiency of Turkey in science and technology, and to increase the role of Techno-parks, SPO supports for public institutions and universities R&D activities have bee initiated. Finally, "The Supreme Council for Science and Technology that had been established in 1983 could attain its first meeting on 9 October 1989" (TÜBİTAK, 1999).

The Sixth Five-Year Development Plan (1990-1994)

Some topics such as supporting R&D activities, advanced technology transfer, production of technology, etc. were mentioned in a broad sense in the plan. The tangible results of the policies iterated in the plan have been the establishment of five Techno-parks, two Advanced Technology Institutes, National Metrology Institute (TÜBİTAK-UME), Technology Development Foundation (TTGV), and Turkish Patent Institute. In addition, it is intended to raise the proportion of GDP, reserved for R&D activities up to 1 percent, and to increase the number of the full time equivalent R&D personnel as 1 per 15 thousand economically active people. The establishment of climate for the university-public-industry collaboration and for this purpose, encouragement of establishment and diffusion of techno-parks were pointed out in the plan. The support of universities both in the basic and applied research would be increased. The precedence would be given to advanced technology areas like bio-technology, ICTs, microelectronics, satellite technology, nuclear technology, advanced materials, etc. (SPO, 1989). Starting from this term, in order to determine the expenses that Turkey has made, the Statistics Institute for the R&D activities and the number of the research personnel, the R&D questionnaires were started and it has been continuing.

The Seventh Five-Year Development Plan (1996-2000)

In accordance with the export-oriented market economy policies, instead of detailed production numbers and regulations, a general framework and policies targeting at the improvement of general competition capabilities of the country, have been intended in the plan, which is a distinguishing approach that separated this plan from the previous plans.

In the plan, this approach has been formulated as 'alternation projects' under the heading of *Progress in Science and Technology*, which outlines several principles and policies appropriate for the contentment of technological needs. At the same time, these principles and policies were in accordance with the 'Science and Technology Policy of Turkey: 1993-2003', a report that was approved by The Supreme Council for Science and Technology at its meeting on the February 3, 1993. For instance, "…while determining management rules of the insufficient financial resources of the country, the priority would be given to science, technology, education and R&D areas because of social, economic and long-term our interests" (SPO, 1995). Furthermore, more concrete targets and policies were also mentioned in the plan; developing generic technologies, knowledge networks & infrastructures, procurement policies of state, venture capital, supporting private sector R&D activities, establishment of technology centres, parks, institutes, and patent rights, etc.

Similar to the previous plan, the target of giving priority to advanced technology industries and high knowledge-skilled sectors are mentioned in this plan as well. The mentioned sectors were design, product development, ICTs, nuclear technology, advanced materials, Techno-parks, space and military technologies, medical science, environment, robotics, biotechnology, and nautical science and technologies (SPO, 1995).

However, the Seventh Five-Year Development Plan could not reach its targets properly either, and the reasons for the failure of this plan have been analysed by SPO (2001). Accordingly, science and technology policy topics could not be taken in hand in accordance with the general economic and social policies; in addition to the insufficient coordination between SPO and TÜBİTAK. There is also the lack of policy implementation tools, which provide the realisation of several aims and policies in the plan. For instance, it was suggested in the plan to increase the portion of the R&D to 1.5 %, by deriving the required amount from GNP. Obviously, this aim necessitated the reorganisation of public resources operations, however, there was hardly any tool in the plan to implement this aim. The issue was only seen as a 'legal/institutional arrangement' in the plan without the exact definition of responsible institutions; in contrast to the general approach and best practice in the world, science and technology were discussed far from the production and innovation. Subsequently, the essential shift from science and technology policy approach to science-technology-innovation approach could not be achieved in a proper sense. Under these circumstances, it is clear that the need for the creation of networks among the science, technology, and production areas have not been taken into consideration.

Beginning with the 1990s, in one respect, the collapse of the Soviet Union, in the other, the rapid economic growth attained by some Far East countries, have led to the interrogation of economic development theories. The adequacy and satisfactory of economic growth and development theories have been discussed, along with their validity. Historically, the development and declining processes national economies and instances from different countries have resulted in new comments on this issue.

From this perspective, these results can be summarised in three key points. The first point is the insufficiency of capital accumulation and development of productive power in explaining the economic growth and development. It is realised that, in addition to this pair, the legal and institutional arrangements, the effectiveness of public administration, social, capital and cultural values, environmental sensitivity, and particularly, scientific and technological developments have important effects on the economic growth. The meaning of the term 'development' has changed, and extended besides solely numerical components like investment cost, amount of production, and number of workers; encompassing qualitative aspects as such.

However, within this overarching view, a factor or a variable is self-evident: science and technology. Particularly, the developments in ICTs and the application of these developments in the production and design of goods and services make fundamental changes on these processes. Theoretical and applied investigations prove that the residual value developed more rapidly with knowledge and technical innovations. It becomes a more dominant view that the factors, that are not numerical, have an important role in economic development and the transition to information society is highlighted in this perspective.

The third point is that how the globalisation process will be reacted. The national development can have positive effects on globalisation in the countries in which the sufficiency of the science and technology reached advanced levels. More clearly, the ways in which the specific conditions of globalisation process can be transformed into national advantage are investigated. At this point, there is no need to discuss the details of globalisation arguments, it will be suffice to remind that in the broadest sense, the rapid increase in the circulation of the goods and services, knowledge, and especially capital in the last decades is described as globalisation. This situation makes obligatory the national economy policy. The governments have to develop national economy policies depending on the level of democratisation in the country. In particular, developed countries acquire national innovative policies in order to obtain more national advantages out of globalisation, as the pre-condition for being able to compete at the international level is to improve the skills and technological sufficiency on the national level and this can only be achieved by an entirely national development approach.

To sum up, globalisation does not always decrease the importance of the national development; on the contrary, it may also contribute to the increase of this importance with the application of appropriate policy tools. However, the national innovation policies are moving to a different dimension, they become multi-faceted, more complicated, and the concept of 'industrialisation' acquires a new content with knowledge and technology. Today, it is not enough just to establish huge industrial units; the technological sufficiency should be strengthened as well. In addition, under such circumstances where multinational corporations are common all around the world, the governments of these countries have to protect the rights of the citizens who elected them, in other words, the 'nation' in the most public sense, described with the citizenry bonds. In this context, a completely 'national' improvement approach is valid for the developed countries. The basis for this policy is reinforcing the competence in national knowledge and technology, as the idea that the main source of the economic development is the assimilation of advanced technologies and developing new ones is the most important focus or discovery of the economic improvement approaches.

The Eighth Five-Year Development Plan (2001-2005)

The Eighth Five-Year Development Plan starts with explaining the general and current developments in the world. The assessments of process of globalisation, knowledge economy and knowledge society are consistent with Fifth Kondratieff cycles, as discussed in the previous chapter. After this assessment, the basic argument of the thesis, which supports the need for harmonisation among the science-technology-industry policies, education/training policies, and R&D policies, is also underlined in the Plan. Furthermore, the situation of science and technology and the targets determined but could not be achieved in the period of the Seventh Development Plan are explained in order to prevent previous failures.

Similar to the Seventh Plan, general framework and policies, rather than detailed production numbers and regulations are stated in the Plan. The targets and aims, which are stated in the plan, also show compliance with the statements of Vision 2023 Project. The objectives, principles, policies of the Plan are outlined as; increasing competitiveness capability of industry at international level; restoring of physical, human and legal infrastructure in order to improve scientific and technological capability; supporting joint R&D activities within a university-public-private sector cooperation; restructuring legal implementations for increasing performance of NIS; supporting R&D activities in the fields of advanced applications such as, information and communication technologies, new materials, aerospace and space technologies, nuclear technologies, oceanography, technologies on utilising and exploiting sea and underwater riches, mega science and clean energy technologies; increasing the number of Industrial Parks, etc. To put it briefly, the aim of the plan in terms of science and technology policies is stated as:

> Strengthening its social structure, ensuring stability, completing structural reforms and realising basic transformations required by the information society, besides benefiting at the highest level from the opportunities created by globalisation and minimising its unfavourable aspects, shall also play a key role in preparing Turkey for the future and in attaining a more effective status within the world (Article 19). (The details of the 8th Development plan regarding science, technology and innovation policies are provided in Appendix A.)

4.4.1. Science, Technology and Innovation System of Turkey

One of the most important institutions among all, with respect to science, technology, and innovation system of Turkey is TÜBİTAK. Founded in 1965, TÜBİTAK co-ordinates, organises, and supports basic and applied research, and is the main body in charge of implementing S&T policy. In addition, the Higher Education Council (YOK), which co-ordinates and regulates higher education institutions; and (SCST) which is the highest S&T policy-making body in the government. S&T policies gained significant momentum only towards the end of the 1980s since the Fifth Plan period, 1985-9, onwards. Financial incentives in the form of tax credits and exemptions for R&D have been put in place and convened first in the year 1989, SCST made proposals for building up the institutional infrastructure; which started to be implemented in 1990.

Following these institutions, several new institutions were established and began functioning in the first half of the 1990s, which include the Turkish Patents Institute (TPI), the Turkish Academy of Sciences (TÜBA), the Metrology Institute (UME), the Small and Medium-Sized Enterprises Support Organisation (KOSGEB), and the Technology Development Foundation of Turkey (TTGV), a public-private joint venture founded with World Bank support to fund industrial R&D projects. In addition, a number of new universities were set up. The institutional infrastructure for S&T now began more or less to be put into practice.

The survey of S&T institutions studied these and related issues in detail. It covered TÜBİTAK; four sector-specific research institutes affiliated to TÜBİTAK, *viz.* the Marmara Research Centre (MAM), the Defence Industries Research and Development Institute (SAGEM), the Information Technologies and Electronics Research Institute (BİLTEN), as well as KOSGEB, TPE, TTGV.

TÜBİTAK continues to be the central agency in Turkey's S&T system. Its headquarters have research grant committees, science fellowship committees, and divisions for science and technology policy and technology assessment. In addition, it has specialised departments that provide technology services and affiliate with other research centres and institutes, among which there are MAM, SAGE, BİLTEN, SAGEM, UME, and others. A re-orientation of aims and priorities has been in process since the late 1980s, emphasising stronger links with the other constituents of the NIS while consolidating its own lead role in that system, the improvement of the infrastructure for S&T information exchange, and more industrial research and pre-competitive development; mostly on contractual terms. Its expenditure has been increasing in real terms since 1990s due to the increased international transfers and revenue from payments for technology services.

A similar trend can be observed in the four sectoral research institutions functioning under TÜBİTAK. MAM was modelled on the Dutch TNO, but evolved into an academic-oriented institution producing scientific papers with little relevance to industrial needs. Following an international audit in 1992, MAM has begun to restructure itself into an organisation for industrial contract research. A more commercial orientation is now regarded as essential, for its own viability in this phase of declining government support and for its ability to make an effective contribution to industrial technology development. The main problem is the lack of R&D culture cultivated within industries themselves. The trends and problems experienced by the other three sector-specific institutions are similar to that of MAMs.

On the other hand, the major objectives of KOSGEB are stated as; to promote entrepreneurship, technology upgrades, and competitiveness in SMEs, which play a very important role in Turkish industry. It has centres offering consultation and training services, spread throughout the country. It also manages techno-parks, which function as business incubators. New entrepreneurs receive financial, equipment and technical support, and can reside in the estate for three years. In relation to the vast numbers of SMEs in Turkey, KOSGEB has very limited outreach. However, this is not due to the lack of financial support, but rather, to that of operating capacity of the organisations. A large portion of KOSGEB's funding comes from income taxes and transfers, and income exceeds expenditure by a wide margin.

TTGV is an important organisation for industrial S&T. Its primary purposes are; to promote industrial R&D, to encourage linkages between industry, higher education institutions, and research institutes, to identify priority research areas that will help close the international technology gap, and to help out industry to utilise and commercialise the scientific research output. It is funded by the WB and the Under-secretariat of Foreign Trade, and has been acting as a disbursing agent for the latter since 1995, with the commencement of government financial support for industrial R&D. The projects are predominantly carried out in the high-technology fields: materials technology, IT, machinery, electro-mechanicals and electronics, and biotechnology.

Higher Education in Turkey

There are 85 higher education institutions in Turkey, among which there are 53 public universities, 23 private universities; and the rest being other higher education institutions such as the military and police schools. The higher education sector represents approximately 60% of Turkey's total R&D expenditures.

Financing Academic Research

Approximately $100 Million public funding is provided annually for academic research. The allocations of resources in financing academic research activities are as follows:
TÜBİTAK's academic research support program, which constitutes 10% of the total public funding for academic research, is regarded as the most prestigious grant within academic circles. TÜBİTAK distributes its academic research support program through eight Research Grant Committees, which represent various areas of specialisation.

- SPO provides financial support for research projects, and for building research infrastructure in public universities, which represents about 40% of the total public funding for academic research.
- Ministry of Finance provides a research fund to each public university, which represents around 40% of the total public funding for academic research.
- Public universities have their own mechanisms for allocating this fund to several research projects within the university.
- The remaining public funding for academic research comes from various ministries and state departments in the form of contract research.

Financing Innovation

In financing innovation facilities, TTGV supports R&D activities in the form of R&D loans. In the early years of the program, TTGV even provided interest free loan financing. TTGV supports projects for a maximum of two years, and the support amount cannot exceed 50 percent of the project budget. R&D loans given by TTGV are extended in terms of USD without any interest, but a fee (2-3% of the project budget) is to be paid for administrative expenses. The loans have to be repaid over three to five years after a one-year grace period.

TÜBİTAK-TIDEB started to provide R&D grants to industrial RTD projects since 1995. In the context of this program, TÜBİTAK-TIDEB serves as the referee institution, while the Under Secretariat of Foreign Trade provides funding, which accrues to the firms at a rate of up to 60% of R&D expenditures in terms of Turkish Liras.

These two programs together were instrumental in doubling the share of the private sector in R&D activities in less than ten years, raising it to about 40%. Finally, both programs aim at supporting marketable and preferably exportable products and provide interaction between the universities and the private sector in order to improve innovation capability of the entire economy.

Public R&D Institutions

On the one hand, there are research institutes on traditional areas, such as agriculture, forestry, veterinary and mining, operating under the Ministry of Agriculture, while on the other hand, there are new public R&D institutes in the newly-emerging areas of ICT, biotechnology, materials, energy and environment, which are operating under TÜBİTAK.

Technology Development Foundation

TTGV, Technology Development Foundation, is a non-governmental and non-profit organisation, founded in 1991. The purpose for the establishment of TTGV was to provide financial incentives to the private companies in order to promote their innovative R&D activities. The initial budget was provided by the Under-secretariat of Treasury from World Bank resources obtained with a loan agreement. Another important role of TTGV is to invest in the Venture Capital Companies (VCC). In this initiative, TTGV aims to make sure that VC (Venture Capital) promotes technology intensive enterprises, and in particular does not shy away from hi-tech companies. TTGV's involvement in the venture capital funds contributes to VCCs investment on technology-based companies in early stage, which are considered risky. TTGV's venture capital activities also aim at demonstrating best practices in operation and investment of VCCs, by proving high return on investments, so that it encourages private investors to invest in VC funds.

Small and Medium Industry Development Organisation (KOSGEB)

KOSGEB was established by a special founding act in 1990, with the purpose of supporting innovation activities and encouraging entrepreneurship. It is a public body acting as both a consultancy service provider and a technology supplier for SMEs, to improve the performance, efficiency, and thus competitiveness by means of technical assistance programs, including training. To achieve these objectives, KOSGEB introduced several instruments, like, Training Centres, Consulting and Quality Improvement Services, Common Facility Workshop and Laboratories, and

Technology Development Centres. These centres have been set up at the university campuses, aiming at supporting technology-based entrepreneurship in a working environment having the infrastructure needed for knowledge intensive production. First launched in 1992, the number of these centres has already reached 20, spreading all around the country.

Techno-parks, Incubators, Knowledge Intensive SMEs

Currently, there are two active Techno-parks in Turkey: METUTECH and TÜBİTAK-Techno-park Complex (The Technology Development Zone, and the Technology Free Zone). After the enacting of the new Technology Development Zone (TDZ) Act, Techno-park initiatives gained a significant impetus, and four new Techno-parks have been founded (Gebze Chamber of Industry, Bilkent University-Ankara, Izmir Institute of Technology and Istanbul Technical University). In addition, KOSGEB established the first incubator for knowledge intensive SMEs on METU Campus in 1993.

Turkish IPRs System and the Turkish Patent Institute

Turkish Patent Institute (TPI) has been established by a Law Decree in 1994 in the legislative reform package of the IPR System, with the purpose of conducting procedures related to industrial and intellectual property rights and providing information and guidance services for the industrialists, R&D institutes, and individuals on these issues.

National Research Network (TÜBİTAK-ULAKNET)

TÜBİTAK-ULAKNET, which was set up in 1996, is catering to the needs of universities and research establishments by providing instant access for universities and R&D establishments to scientific resources. It also aims at facilitating the cooperation among R&D personnel both domestically and internationally, and integrating research and education.

National Metrology Institute (TÜBİTAK-UME)

National Metrology Institute (UME) was founded in 1992 by TÜBİTAK with the main objective of establishment and maintenance of national standards for all measurements carried out within the country, and calibration of the measurement standards and devices of second-tiered laboratories. UME fulfils the requirements of Turkish industry by providing services in calibration, testing, training, consultancy, repair, maintenance, and by supplying specialised measurement equipment for high-level laboratories. Moreover, UME provides the necessary interface to the international network of professional measurements, which is essential for international trade and removal of technical barriers in trade.

University-Industry Joint Research Centres (TÜBİTAK-USAMP)

This program has been launched by TÜBİTAK in 1996 with the aim of initiating and fostering university-industry cooperation, giving priority to research areas meeting the needs of the industry. The centres are funded jointly by TÜBİTAK and the participating firms. The private sector side of the consortium is to involve at least three companies or an umbrella organisation (association, chambers of industry, etc.) collaborating with a university. The participating university provides research infrastructure, as well as space and human resources. The research topics are determined by the technical committees composed of experts from both industry and university. Pre-competitive research is the main activity of these centres, although it is possible to conduct contract research for a member company.

4.4.2. Assessment of Turkey's NIS

When the subject matter is analysed from an elevated perspective, it is revealed that the lack of Turkey in establishing a national innovation system results from the basic elements of the three subsystems that are supposed to found this system (4.4.1). These elements are; the industrial sector as the primary component of the production sector, universities as the essence of science and technology system, and the political/bureaucratic cadres that form the fundamental motivators of the public administrative system.

The university system, the basic element of science and technology system in Turkey will not be discussed in detail for our purposes; not because they are not held responsible, but rather, as this would exceed the scope and limits of this text to discuss universities and their structure; therefore, structural characteristics of the remaining two elements will be analysed here. Nevertheless, before starting the discussion, it would be useful to remind one point; although they do not have a direct role in the creation of the circumstances which they have also been in particularly after 1990, and which had an effect on the lack of attaining sufficient success in this regard; the structural characteristics of these elements themselves had an important part in this failure. Below, some generalisations will be drawn in the light of expert opinions on this subject matter in order to revise the reasons for this failure.

The thread, textile, and clothing industries have a strategic importance for Turkey due to the part they played in employment and export. The industrialists/experts in this field highlight some important points, such as; "In 2005, the quotas on textile and apparels imposed by US and EU on non-EU member countries will be abandoned. When these quotas in both markets diminish, Turkey will face serious difficulties due to her Far-Eastern rivals" (TÜBİTAK, TTGV, TÜSIAD, 2000).

Another strategic area for Turkey is the automotive sector and its related by-industries. It is obvious the driving role that these industries have been playing particularly in the production industry of Turkey. On the other hand, although Turkey still keeps her position as a centre of production, considering the worldwide developments, it is stated that:

> R&D and post-purchasing services are gaining an increasingly important role in creating the added value in automotive and related sectors, compared to the production side. This denotes for Turkey that there are new production centres emerged as rivals in the world, and if Turkey does not become more competent in creating an added value, it seems a possibility that her role and importance will decrease in this regard. Moreover, unless the necessary measurements are taken particularly in the automotive by-industries, where the cost of investment is relatively low, the foreign investment will shift to other countries. In other words, Turkey is a technology importer and user country, however, primarily with the 8th Development Plan, the target is set so as to be rather a 'technology production centre' instead of a 'production centre' (TÜBİTAK, TTGV, TÜSIAD, 2000).

The generic technologies like ICTs are regarded as the locomotive sectors of our time and the acquiring of innovation capability comprises a vital importance in this regard. On the other side, the portion of intellectual property in the 'info-telecommunication' products used in Turkey is 5%; while it should be at around 50%. When it is considered that these technologies are of generic characteristics and thus they affect almost the entire economic and social activity areas, it can be concluded that the weakness in this respect has been and will continue to be reflected at all industrial branches.

After this brief information on some sectors, a glance at the DIE (State Institute of Statistics) Production Industry 1998-2000 Technological Innovation Activities Query Results would help to understand from a broader perspective the capability of the production sector. One point should be underlined in the analysis of the results: in this query, the activities of the firms that provide innovation, 'product or production process innovation', as cited in the query, by purchasing license and new machinery, or only by training are also considered as 'innovative activities'. The technological innovation data have been compiled in compliance with the definition and methodology set in Oslo Manual, which suggests an international standard method.

In the mentioned results, it is figured out that between the years 1998-2000, 29.4% of all public and private sector workplaces with 10 or more personnel, performed technological innovation activities. Of these workplaces that carried out innovation, 26.3% implemented product innovation; 36.4%, process innovation, and 37.3% applied both product and process innovation activities.

It is observed that the rate of implementing technological innovation increases with the scale of the workplace. When this rate was 20% for the workplaces with a personnel number of 10 to 49, it increases up to 40% in workplaces with personnel ranging from 250 to 999. In the workplaces with more than 1000 personnel, the rate of those that underwent technological innovation is approximately 60%.

According to the economic activity branches, the first six sectors with the highest rate of technological innovation are; office & informatics machinery, unclassified electrically operated machinery and equipment production, other transportation vehicles, unclassified machinery and equipment, medical equipments, sensitive and optical tools and watches production, chemical substances and products, have achieved over 44% technological innovation.

The latest six sectors according to the rate of implementing technological innovation, which constitute the 41.5% of the total production sector, have however fell under the total rate of production sector, which is 29.4%. Tobacco products, apparel goods production, fur fabrication, press & print media, textile goods production, other unclassified productions, furniture, leather goods and shoes sector, are classified among these sectors.

Among all the technological innovation expenses of Turkish industry, the portion of the expenditure on the R&D activities implemented in the workplaces is 26.5%, whereas the portion of expenses of the R&D services assumed from out of the workplace is 2.7%. The other items in the technological innovation expenditure are:

- Purchase of machinery equipment regarding product or process innovation (62.2%)

- Industrial design and other production preparations (2.8%)
- Other technology purchases (1.4%)
- Training expenses regarding technological innovation (0.8%)

From another viewpoint, it is observed that there is an increase compared to the past years in the R&D activities of the Turkish Industry, in other words, in depending its innovation activities on its own R&D activities; however, this is still below the sufficient level. This situation points at the serious weakness to gain competitive advantage in world markets. Operating under the license purchased from a foreign company, and usually innovating its process at the same time, a local firm may attain a level to produce a new product, and achieve to export. However, this is a limited process, the boundaries of which are related to the success of the firm in the markets. That is to say, it cannot purchase the license from the same firm again and as it cannot innovate its product either, it loses the position achieved in the foreign markets at the quickest time period. This has been observed in Turkey with the incidents of ARÇELİK and Profilo. ARÇELİK established its own R&D, whereas Profilo did not, which had to hand its shares over to its foreign partner.

Another interesting fact regarding R&D activities in Turkey is, while no substantial resource is reserved for R&D activities, 20% of the resource reserved for defence is spent on the R&D expenses of the purchased knowledge/product. The defence expenditure of Turkey, although fluctuate in years, is approximately 4-5 million USD on average in recent years, which means 1 million USD is spent in that regard. However, unfortunately, Turkey does not reserve that amount for the R&D activities (TÜBİTAK, TTGV, TÜSIAD, 2000).

On the one hand, it will be useful to remind the fact that it will not be possible to attain an R&D based, sustainable proficiency in innovation without the establishment of a functioning national innovation system. On the other hand, the whole picture indicates that the Turkish industry has not performed satisfactorily with respect to innovation activities. Moreover, beyond innovation, it is evident that the industry faces serious difficulties even in performing its raison d'être, i.e. production function. In other words, that the climate in Turkey is not appropriate enough for production purposes, which may also indicate a number of other external factors that cannot be assigned directly to the industrialists may have played their part in the emergence of this inappropriate climate for industrial production. As a result, unfortunately, the first of three branches of the helix supposed to establish the national innovation system reveals not to be functioning properly.

When looked at the other branch of the helix, political/bureaucratic cadres, it is observed that developments in the world are followed up to a certain degree. As an instance, 'The Science and Technology Policy of Turkey' document has been accepted, which was prepared by The Higher Council of Science and Technology, leaded by the Prime Minister or Deputy Prime Minister, among the members of which there are a number of key ministers and high rank bureaucrats. In addition, in the direction of this policy design, a series of decisions have been taken and put into action for the national innovation system to be activated, in the period between the years 1993-2003. On the contrary, when considered the discussions until here, it is observed that the enormous gap between the decisions taken and the implementation phase (the details of gap are analysed utilising Aykut Göker's study (2003) in Appendix B).

The extent to which the decisions taken in The Science and Technology Policy of Turkey: 1993-2003 and accepted by the Science and Technology Higher Council on February 3, 1993, could have been realised within 10 years, are analysed in Appendix B in detail. To put it concisely, considering the evaluations made, it is possible to state that there are several successful applications such as 'R&D Support to the Industry' and 'increase up to the higher ranks in the International Science Citation Index', however, it is not possible to mention the same success in the realisation of the targets and their consequences.

4.4.3. Vision 2023

Parallel to these developments, while it is only in the late 1980s, and even more so after 1990, there was a serious attempt to draw up a comprehensive S&T plan, some important technology institutions had been set up before 1985. Related to these developments in the world, the role of TÜBİTAK has been revised in a fashion to emphasis more the broadening R&D infrastructure by training researchers, by establishing public R&D facilities, and creating a research tradition by encouraging, supporting, and implementing research activities almost exclusively in the academic field to catch up with the critical values of R&D indicators. In short, the Turkish S&T system was regulated by a supply oriented S&T policy (science-push approach) for a relatively long span of time.

The first detailed S&T policy document was prepared in 1983, "Turkish Science Policy: 1983-2003", and it was regarded as the first attempt towards defining "critical technologies" in Turkey. This document was underlining the role of technology for development, and making suggestions regarding priority areas of technology. Moreover, this document led to the creation of a new institution in 1983, the Supreme Council for Science and Technology (SCST), as the highest S&T policy-making body of Turkey.

Although SCST was established in 1983, the active role of SCST, in preparing and formulating national science and technology, was started mid-1990s. In 1993, SCST approved the document entitled "Turkish Science and Technology Policy: 1993-2003". This document emphasised basically the important role of S&T in surviving the vitality of national economy, sustaining economic growth, upgrading the living standards, and international competitive advantage, adopted a national S&T policy for the next ten years. So, it is accepted as a turning point in the S&T policy era in Turkey, from "building a modern R&D infrastructure to "innovation oriented" national policies. In 1995, this document has been re-arranged and turned out to be "The Project for Impetus in Science and Technology", which formed the S&T chapter of the Seventh Five Year Development Plan.

The distinctive feature of the policy that was adopted after 1993 incorporated the purpose of perfection in science & technology and also the ability to transform this perfection to social benefits through innovation. Turkey's perfection in science and technology and also its ability in the transformation of the science and technology to the economic and social benefits depended on its success in the formation of the National Innovation System, the vision of which should incorporate:

- Reconciling with science and technology
- Perfection in producing science and technology; obtained the ability in the transformation of science and technology to economic and social benefits (i.e. innovation)
- Improving Turkey to a prestigious state among the countries that contribute to science and technology worldwide, which is the shared heritage of humanity.

The main theme of the science and technology policy adopted after 1993, as depicted in the items above, is constituted by the foundation of the NIS. Therefore, the application agenda accepted in SCST assembly in 25 August 1997, to which new items were added in the assemblies in 2 June 1998 and 20 December 1999, is comprised of the immediate precautions for the foundation of the NIS, which is a necessary condition for the perfection in science, technology, and innovation.

However, although many developments have been achieved in terms of both S&T indicators and institutional framework since 1993, unfortunately the targeted success could not be realised due to the reasons such as the lack of a shared S&T vision of governments, academia, and the public & private sectors, and thus, their lacking commitment to the policies adapted.

Therefore, under these conditions, the needed steps have been taken by SCST in its sixth meeting on December 2000, which aimed at formulating new national S&T policies and priority areas for achieving an innovative economy and society in 2023. The project entitled "Vision 2023: Science and Technology Strategies" has been approved by the Council in its seventh meeting in December 2001. Vision 2023 project involves the first national foresight exercise of Turkey ever, together with three more sub-projects that aim at collecting and evaluating data on the current science, technology, and innovation capacity of the country.

The main theme of Vision 2023 project is the "creation of welfare society which is capable in science and technology, able to produce newer technology and able to convert technological improvement into social and economic advantages". The planned studies of Vision 2023 projects are; determination of science and technology position of Turkey; of long term science and technology trends in the world, of demands of Turkey in science and technology regarding Vision 2023 projects, of essential strategic technologies which provide the achievement of these targets, and finally, suggestion of policies which would help develop and/or obtain these technologies. Therefore, it is an ongoing project and as in Figure 15, it involves four sub-projects, which are; "Technology Foresight", "Technological Capacity", "R&D Manpower", and "R&D Infrastructure".

Technology Foresight Project is the backbone of the Vision 2023 Project. The results of this project will be utilised with the results of other three projects, which aim at the determination of existing science-technology situation and of the future potential of Turkey, in order to prepare to "2003-2023 Strategy Documentation". This documentation will encompass the science and technology vision, strategic technologies of Turkey, together with the R&D priorities and policies of these areas that create and/or improve Turkey's capability.

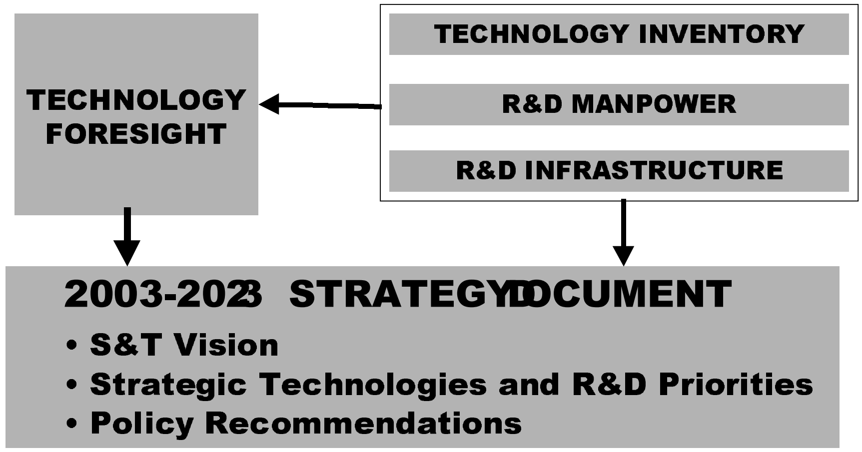

Figure 15 Vision 2023

Source Tümer and Taymaz (2001)

Steering Committee, consisting of 65 representatives from 27 governmental institutions, 29 industrial organisations, several NGOs, and 9 universities, has been formed as the highest organisational body of the Vision 2023 project. The Steering Committee guides the project by taking the strategic decisions and approving the reports and policy recommendations generated during its implementation. Operational and budgetary decisions are taken by the Executive Committee, which is chaired by the President of TÜBİTAK, and brings together three representatives of the Steering Committee with the related administrative officials of TÜBİTAK. The Project Office formed within the Science and Technology Policy Department of TÜBİTAK is responsible for the implementation of the project. Other organisational bodies include national and international advisors and panel chair groups. The methodology adopted for the Turkish Technology Foresight Project involves panels, a two-round Delphi survey to be executed by the Project Office in co-ordination with the panels. Ten panels were formed on certain socio-economic fields and two others on cross-cutting issues of education/human resources and environment/sustainable development. Possibly, a number of panels will be set up at a later stage on generic and emerging technological areas. In its first meeting in April 2002, the steering committee decided the following 12 technology foresight panels to be formed, which are stated in Figure 16.

The panels were initially assigned the task of building their own visions of future, and listing the groundwork technologies. At this stage, around 200 panel meetings and enlarged workshops took place between July 3, 2002 and January 24, 2003. On January 28, 2003, it was announced the completion of preliminary panel reports and the interested groups were invited for their criticisms and contributions to the preliminary panel reports. This wider consultation period also involved several activities planned by each panel for disseminating their initial works among the related actors in the field. The preliminary reports of the twelve foresight panels are presented in a common format and addressed the following points as shown in Figure 17, regarding their areas of interest.

1. Education and Human Resources
2. Environment and Sustainable Development
3. Information and Communication
4. Energy and Natural Resources
5. Health and Pharmaceuticals
6. Defence, Aeronautics and Space Industries
7. Agriculture and Food
8. Machinery and Materials
9. Transportation and Tourism
10. Textiles
11. Chemicals
12. Construction and Infrastructure

Figure 16 Topics of Technology Foresight Panels

- Trends and issues, which are likely to affect the world and Turkey
- Assessment of Turkey's current standing (SWOT analysis)
- Turkey's vision for 2023
- Socio-economic objectives to be achieved in order to realise their visions
- S&T competencies and underpinning technologies needed to achieve the socio-economic objectives

Figure 17 Planned Studies of Vision 2023 Projects

Delphi process aims at addressing the likelihood of achieving the envisaged technological developments as well as testing them against a set of criteria determined by the Steering Committee. All panels, with the only exception of the Education and Human Resources Panel, prepared more than 1200 statements that were likely to play an important role in realising their 2023 visions. The Project Office, in close co-operation with panels, carefully examined all statements for clarity of expression, technology and policy relevance, and double postings. The final list included 413 unique statements grouped in 11 questionnaires, 104 of which appeared in more than one questionnaire. The first round of the Delphi process commenced on May 12, 2003, and completed around mid-June in the same year. The forms were posted to more than 7000 related people, of different professional standings and expertise, who could reply by filling out either the printed versions of the questionnaires or the on-line electronic versions. Those respondents, who have fully expressed their opinion on at least five statements are offered a small promotion; one-year subscription to one of the monthly popular journals of TÜBİTAK, 'Bilim ve Teknik (Science & Technology)' and 'Bilim Çocuk (Science Junior)'.

The response rate of the first round of the Delphi process was 32%, with a total amount of around 45.000 responses received for the 415 statements. The panels have been supplied the results of the two round Delphi survey for their review and evaluation. Each of the ten sector panels have reviewed the results and responded to them in their final reports, which were submitted on July 24, 2003 to the project office. Panels, although generally taking into consideration the results of the Delphi survey, have been free to comment on, or even disregard them and to reflect their own interpretations in the final reports. Each panel has also submitted, in their final reports, technological roadmaps prepared on a format decided by the Project Office, for attaining the envisaged technological developments in each "Technological Activity Area". The sector panels have drawn up a total of 94 road-maps. Having collected the final reports of panels, the Project Office has prepared a "Panels Synthesis Report" on the findings and recommendations of all panels, thus concluding the technology foresight exercise. In the synthesis report, all the Technological Activity Areas proposed by the panels, have been grouped under the following four main goals, which are stated in Figure 18.

1. Enhancing the competitiveness of the Turkish industry
2. Improving the quality of life of Turkish citizen
3. Sustainable development in Turkey
4. Strengthening the technological infrastructure in order to accelerate transition to a knowledge-based society

Figure 18 Main Goals

As a final step for the preparation of the "Science and Technology Policies Strategy Document for the Year 2023", all "Specific Technology Fields", together with their sub-fields, playing crucial role in the realisation of each of the Technology Activity Areas, in which Turkey has to improve/gain capability, or which she has to develop, have been listed and grouped under the following eight main headings, stated in Figure 19.

Strategy groups, each made up of about 20 experts, have been established under these eight technology fields. In addition to these strategy groups, another strategy group on education and human resources has also been established. The task of strategy groups is to prepare “technology roadmaps” for those specific technology fields they assume as priority fields, and are of critical importance for the realisation of the technology activity areas proposed by the panels.

1. Biotechnology and Gene Technologies
2. Information Technologies
3. Nanotechnology
4. Mechatronics
5. Design Technologies
6. Production Methods and Machinery
7. Materials
8. Energy and Environmental Technologies

Figure 19 Main Areas

Finally, the 20-year Science and Technology Strategy Document based on the findings and recommendations of all four sub-projects and highlighting the technology roadmaps on priority technology fields, will be prepared and submitted to the Supreme Council, and subsequently to the Government for consideration and adoption, in September 2004.

In accordance with the Vision 2023 Project, SWOT analysis of Turkey was carried out in 25 December 2003 and announced by S&T Workgroup 2004, (Turkey Economy Congress) in order to determine Turkey’s strengths, weaknesses, opportunities and threats; in other words, it is intended as a starting point for discussion and further elaboration, which aimed; determination of strategic technologies and priority areas of R&D, formulation of science and technology policies of Turkey for the next 20-year period; determination of national capability levels in these technologies; determination of measurements which are taken by government(s); and finally, determination of national programs and projects. According to this study, analysis of Turkey’s strengths, weaknesses, opportunities and threats in terms of science and technology are stated in Table 11 and the discussion of this analyse will be made in Conclusion part of the thesis.

Therefore, the study of national innovation systems offers new rationales and new approaches for government technology policies. Most government intervention in the technology area has been directed towards correcting market failures or the tendency of the private sector to underinvest in technology development due to the inability of firms to capture all the benefits from such investments. In the interest of maximising returns to the general public, technology policies have focused on stimulating or supporting R&D spending by industry through instruments such as R&D tax credits and subsidies. The concept of national innovation systems directs the attention of policy makers to possible systemic failures, which may impede the innovative performance of industry. In other words, the concept of NIS has come to prominence for several reasons. One is the growing economic importance of knowledge, with many economic activities becoming increasingly knowledge-intensive.

A second and closely related reason is the widening range of institutions involved in knowledge generation. Third is the emerging interest in systems approaches to the study of technological development, due to the widely recognised limitations of the traditional linear model of innovation. Furthermore, according to Edquist (1997), contemporary innovation poses new problems for science policy regimes including:

- the need for institutional flexibility in response to future demands;
- the enabling of organisational and managerial change;
- the encouragement of new types of network
- the effective and appropriate selection of socio-technologies for the future;
- the effective and appropriate management of knowledge flows within and between innovation actors.

On the other hand, it has been argued that three main trends have been driving the spread of technology foresight. The first derives from the increase in the number of 'players' in market economies, which, together with the enormous variations in salary differentials and the trend toward globalisation, has accentuated the pressures of economic competition. As a result, innovation is becoming ever more important along with the development of knowledge-based industry and services. Science and technology have an increasingly influential role to play in responding to these competitive pressures. Second, government spending in most industrialised countries is coming under growing strain, leading to demands for more accountability and value for money. Science and technology, with their inevitable demands upon the public purse, have not been immune from such pressures. Since no country, however rich, can afford to pursue all the possible opportunities in science and technology, we need better mechanisms for choosing between competing alternatives, and for linking science and technology more closely to economic and social needs. Third, we are witnessing changes in the nature of the knowledge production process, as a consequence of which we need better interactions among researchers, and between researchers and research users.

Table 11 SWOT Analysis of Turkey

Strengths

Human Resources	• Young and dynamic population, open to developed and new technologies, with high adaptation capability. • Existence of a science and technology society, integrated to international society • Existence of international scientists and industrialists, working in the field of strategic technologies
Natural Sources	• Having a strategic location and geography • Potential of rich natural resources which can be used as raw material (strategic ores, rich wild life, aromatic plants) and renewable energy resources • Existence of agricultural potential which would provide input for food sector • Potential of production based on variation of species and construction of forest ecosystems • Situation of our natural resources, historical and cultural values which are not polluted or degenerated in an irreversible way yet
Competitive Power of Industry	• Existence of industrial firms, open to international cooperation • Competitive labour costs created by the younger population • High potential in domestic market • Large domestic market, which satisfies cost effective provision depending on R&D • Export and investment experience in consumer electronics, automotive, textile sectors in global market; development of export oriented investment and production of consumer durable products • The existence of consumer durable products sub-industry which have achieved quality culture and boosted its productivity studies because of main industry pressures on cost reduction and quality • Existence of a developed textile industry which has international competition experience, ability of rapid decision making and flexible, small scale production, high capability of technology and fashion adaptation. • The potential of chemistry industry to become “advanced technology production centre” for EU countries and also to produce high value added goods production by using national sources • The transformation advantage of medicine row product industry, which existence plants in accord with the modified productions, into pharmaceutics biotechnology
Science, Technology and Innovation Infrastructure	• Despite its need for multi dimensional development, existence of strong elements of national system of innovation such as developing information and communication infrastructure, Techno-parks, university-industry partnerships for research centres, firms with the structure to develop original products and production techniques • Existence of mechanisms to encourage R&D • Existence of technologies and know-how to prevent pollution

Weakness *(Table 11 cont'd)*

Human Resources	• Wrong policies in employment, personnel training, and management • The deficiencies in the intermediary staff education who play an important role in technology development and application • Lack of research personnel for the critical high tech fields such as molecular biology, genetics, new materials • Rapid growth of population, migration and unplanned urbanisation
Political, Managerial, and Bureaucratic Obstacles	• Domination of central management systems instead of a participative management • Lack of long term policies and strategies • Industrialisation and technological development strategies are not supported by public provision policies • Lack of policies about information technologies, human resources, and diffusion of information technologies with the leadership of public sector • Insufficient legal system which cannot answer modern needs, deficiency or populist approaches in regulations, timing problems in defining rules about market issues • Bureaucratic infrastructure, creating problems for foreign investment
Weaknesses of Industrial Structuring, Infrastructure and Development	• Macroeconomic instability • Continuing industrialisation and lack of understanding the value of technology input in production • Lack of sector based industry policies • Insufficient capital accumulation and financial infrastructure, lack of entrepreneur supporting mechanisms such as risk capital. • Dependency to abroad in technology use, tendency to prefer ready-made systems and technologies and lack of self-confidence in technology production • Inability of economic structure to get rid of old and polluting technologies (industry, fuels, etc.) • Inability to create trade marks • Technology and R&D activities exist only in accordance with the desires and directions of main industry, they cannot become a routine.
Lack of Coordination and Cooperation Capabilities	• Weak coordination and cooperation between institutions, strong personal preferences and lack of team work and organisation • Weak industry-university relations, incapability in marketing the research results • R&D activities carried out by limited financial resources and without satisfying the necessary coordination • Insufficient research for foreign markets and lack of cooperation for foreign markets in terms of production strategies which at last results in weakness in competition with multi national firms • Insufficient web structure and database, which are necessary for collecting, storing, operating and generalising information and data countrywide
Insufficient Control	• Lack of unbiased experts and institutions, insufficient control
Cultural Factors	• Documents of strategy and policy do not tell about 'how'; do not relate to ongoing procedures, they just spell out the wishes • The wide spread approach of defining the problems, rather than solving them • Insufficient industrial R&D culture and insufficient social conscious for R&D, social prejudice • Lack of understanding importance of environment and environmental information in every level of society even decision makers

Opportunities *(Table 11 cont'd)*

Opportunities Created by Globalisation	• European Union membership • Participation in the 6th framework program of European Union • Nearness to the markets of EU countries, Russia, and newly independent countries, and evolving relations with these countries in terms of cooperation and trade • Opportunity to become an 'energy bridge' with the ability to create new production fields • Mobilisation of capital as a result of globalisation and its search for investment • Market opportunities created by liberal international trade • Becoming attractive for foreign investment because of population, experience, research potential, labour cost, transfer payments, etc.
Technological Opportunities	• Dragging national project opportunities: defence provision programs, national R&D infrastructure programs, national information and communication infrastructure programs like ULAKBIM, Kamu-Net, Okul-Net, metropolitan infrastructure projects, R&D aids in industry, transfer payments for projects etc. • Opportunity to enter new service and application fields as a result of fast development of informatics technologies • Opportunity to gain technological capability and excellence with the knowledge of global producers in the period of redirection of production from developed economies towards peripheral economies in automotive industry • Together with the arising new kinds of energy and new technologies in energy field • Global producers, working in Turkey, may provide technology and information transformation
Opportunities Created by Defence Industry	• Opportunities that will be offered by defence industry field for high-tech product and service production, and for developing the science and technology infrastructure. • Possibility using products or services developed in defence field in civil sector

Threats

Population Growth and Brain Drain	• Brain drain of capable work force or its employment in fields other than its expertise • Insufficient education of young population
Threats Created By Globalisation	• Political instability and terrorism in our geography • Global economic fluctuations • External political effects, pressures and directions • Problems in EU membership process • Liberalisation of international trade and increasing competition in the market • Faster development of competitor countries and their absorption of global investments • Increasing market domination of multi national firms • Distance between Turkey and U.S. or developing Fareast market • Failure in the expected foreign investment flow because of the failure in satisfying macroeconomic stability and avoiding managerial weaknesses
Rapid Development in Science and Technology	• Exponential increase in science and technology • The blocked technology access channels which are created by develop countries

As a result, the momentum behind current foresight programmes in both government/public and private sectors can be said to be derived from the need to confront, take stock of, and engage with the risks and uncertainties of the innovation system.

Since 1990, foresight has spread rapidly and this is also true with respect to Turkey where technology foresight has been adopted on a large scale for reasons similar to those pertaining more globally. Comparisons of the Turkey experiences with foresight in the world point to a number of lessons. First, technology foresight can be used for different aims, reflecting the economic, political, and cultural circumstances of the country concerned. Second, considerable benefits can be derived by learning from the experiences of other countries with foresight, at the very least reducing the risk of failure. At the same time, however, it is essential to tailor the foresight process to local circumstances and needs. Third, if the foresight process is well designed, it can result in considerable process benefits, in particular in relation to the 5Cs of better communication, greater concentration on the longer term, more effective coordination, the development of a level of consensus on desirable futures, and the generation of the commitment necessary to translate the results of foresight into action. Fourth, it is virtually impossible to get foresight right the first time; indeed, at this stage of its development, there are few reliable guides as to just what constitutes success in relation to foresight. In the case of the Turkey analysed here, the initial attempts at foresight have suffered from several shortcomings.

Therefore, linking the Turkey's foresight experience with the wider literature on technology and innovation policy, it has been argued that technology foresight has a potentially important role to play in relation to national innovation systems, strengthening them in terms of the capacity to learn and innovate. It was examined why the concept of the national innovation system has become more important as a result of such factors as the transition toward the knowledge economy, and the increasing range of institutions involved in research, technological development, and innovation—institutions which need to exchange information, learn from one another, form partnerships, and so on.

Coming back to innovation system again, Prof. Dr. Erol Taymaz, in his "Ulusal Yenilik Sistemi: Türkiye İmalat Sanayiinde Teknolojik Degişim ve Yenilik Süreçleri (National Innovation System: The Processes of Technological Change and Innovation in the Production Industry of Turkey) (2001) quotes that:

> The concept of 'national innovation system' started to be used particularly in 1990s in the development of technology and innovation policies. While including all institutions that contribute to the technological development process, this

> concept had been very effective as it brought to the agenda the international competitive power of the country and its position in the international collaboration.(...) in 1990s, this concept has been used by a number of international institutions like OECD and EU as well, in the development of technology and innovation policies.

While the expressing thoughts on the 'National Innovation System' and development of innovation policies in OECD and EU as such, Taymaz indicates the following on what Turkey should do "to sustain its economic development and increase its competitive force".

In order to sustain its economic development in the long-run and increase its competitive force, Turkey has to reinforce its technological capabilities as soon as possible, provide productivity increase by means of technological innovations, transform its production and export structure to technology intensive products with the development of technology intensive industries...such a transformation would not happen itself. There is a need for a clear development strategy, comprehensive industry, technology, and innovation policies, and an effectively functioning national innovation system in order to reinforce the technology development and absorption capacity of production industry and the economy as a whole. Having made this analysis on the principles that Turkey should attain "to sustain its economic development and increase its competitive force", Taymaz follows such an approach for the path Turkey followed after 1990:

> The establishment of the National Innovation System has been brought to the agenda particularly by TÜBİTAK in 1990s and a systemic approach has been adopted. In this direction, with the mediation of SCST, policy proposals have been developed and some of these have been put into practice. One of the most important implementations among those is the support for R&D activities through the means of credits and donations provided by TÜBİTAK-TIDEB and TTGV.

It is open to discussion whether the opinions that Taymaz denoted here have been realised or not. The study made in the preparation of this text demonstrates it is unfortunately not possible to suggest that Turkey has achieved to establish a systematically operating National Innovation System. It should be admitted that except for some programmes, e.g., R&D support for industry, the system could not be established properly, and the necessary measures could not be taken on time. As an instance, it has taken four years to deliver the Law on Regions of Technical Developments. Moreover, a number of draft policy proposals developed since 1995 on some critically important technology areas for Turkey, have been left in shelves, such as: TÜBA-TÜBİTAK-TTGV Science-Technology-Industry Policies Platform, Report of Study Group on Science and Technology Policies in Informatics

Field, October 1995; TÜBA-TÜBİTAK-TTGV Science-Technology-Industry Policies Platform, Report of Study Group on Science and Technology Policies in Advanced Materials: Policy Proposals for Turkey, September 1995, and a very significant main plan in this framework, TUENA (The Main Plan for National Innovation Infrastructure in Turkey), etc., the list can be extended.

However, considering the discussions until here, it is possible to put forward the basic reasons of the gap mentioned above. Before, it will be useful to remind, particularly in the light of the analyses I made in this chapter, that in a number of studies carried out to date, I believe, the designers are obviously aware of the fact that in order the country to develop its capability in science and technology, vast arrangements should be implemented in a number of fields ranging from education to finance. Moreover, they paid the necessary attention to the systemic integrity stemming from the nature of the work. It is determined that the designers regard science and technology more or less as plannable, strategic variables that could be utilised for the economic growth and social improvement. This text suggests that there is no fundamental mistake in the studies analysed; as since 1960s, none of the governments challenged any of these studies due to such a reason as their being mistaken. On the other hand, based on the studies analysed in this text, the perceived the reasons for these gaps are:

It is not yet fully comprehended by most politicians and bureaucrats that: a) science and technology policies have to be designed and implemented in a systemic integrity with a number of policies in certain coordination. For example, the failure in establishing the necessary cooperation and the required mechanisms to sustain, of TÜBİTAK and SPO, whose collaboration is essentially significant in both design and implementation phases of science and technology policies, b) science and technology policies have to be considered on a long-term basis. If SCST is taken as an instance to see the detailed picture, it should be pointed out that the inefficient operation of SCST is affected as it could not find a full acceptance, not only by SPO, but also by the other sections of the bureaucracy and more important than that by the governments. This resulted in its failure in enjoying its authority as the Council cannot gather in a frequency sufficient to be effective, or the authority given to the Council by the decree of law cannot be realised in practice, and this authority is not utilised by another state organ. Then, this denotes that Turkey does not implement a policy in the field of science and technology (and thus, in innovation) that has a systemic integrity, sustainability, and stability. In fact, she does not even possess such a policy; as she continuously delays the issue of capability in science and technology, and therefore, detaches from the point where she can have a say in her own future. There is no example similar to Turkey among the countries that claim to have say on their own future.

The bureaucratic cadres that acquired a certain capability in this field are eroded by each government and/or administration change. Additionally, the institutions cannot catch up with the changing circumstances, as they do not possess learning organisation characteristics. In other words, this situation caused by the frequent changes not based on merit, in the cadres requiring administrative skills and expertise, results in the deficiencies of the institutions in evaluating and redefining their missions according to the changing needs and requirements, and their lacking in timely reorganisation. Traces of these deficiencies can be tracked in the failures of various public activity fields, which are subjects of science and technology policies. In brief, unless it is prevented the political power expose itself in the search of political premium and populism in the staffing of the areas that require expertise in the first place, it will not be possible to attain the proposed targets in science and technology policy designs; regardless of their appropriateness.

Another important reason for this gap is that the institutions are lacking an understanding of 'long-term vision'. What is meant here is the problem of how to find new ways out of consideration of opportunities and possibilities that could only be put forward with long run estimations/foresight, in a society where the majority is exhausted running after the daily events and do not ponder beyond short run as a customary habit. Short-run tendencies also give a hard time to decision makers putting them into a vicious circle, as they do not leave the routine approaches, but they cannot solve the problems with routine practices and they are left without resources to solve those problems due to their insistence on routine approaches, either. Thus, the result is their inability to go beyond being 'imitators'. However, the required practice is totally opposite to this approach. That is, it is required to have institutions that could monitor and evaluate strategically the performance of the plan and develop and vary the policy implementation tools timely according to the national and regional needs and circumstances. On the contrary, substantially SPO, which is the key actor in the realisation of the 5-year development plans and Annual Implementation Plans, lacks such an essential quality. It is emphasised by the former SPO Consultant, Orhan Güvenen himself that SPO should redefine its mission and has to "transform into an institution that is able to execute strategic planning in the changing world conditions accordingly" [Güvenen, 1999].

As can be observed in the world practice, councils similar to SCST are established to generate science and technology policies and provide the co-ordination of this multi actor game. However, a strong executive organ, which may be a ministry or ministries, in some cases, undertakes the duty of functioning; in order to put into effect the decided policies and with the close monitoring of the implementation, to realise the required intervention timely. The absence of such a ministry in Turkey and the high expectations from SCST to carry out the functions that could only be realised by a ministry is a wide accepted reason for the explanation of the failure. Between the years 1971-83, the Ministry of Industry was named as 'Ministry of Industry and Technology'; however, this did not have any significant effect in practice. On the other side, a number of experts who considers that a ministry for these purposes is a must had difficulties in defending this idea on practical grounds as they do not trust in the political power and the efficient operation of the ministries. However, in the Turkish practice, in order SCST be operative, or such a ministry to be effective in the implementation of its expected mission, it is necessary to provide the requirements of the entire policies as discussed in this thesis.

Lastly, there is a requirement for the implementation of participatory methods in the policy design process as well as other policy areas in order to, the lack of which is a substantial factor in the formation of the gaps in the implementation of science and technology policies. The encouragement of these participatory methods will also contribute to providing the society to pay interest in their own issues. For this purpose, it is obvious that other additional mechanisms are needed besides an operative SCST and establishment of a specific ministry, in order to expand the participation in the policy design process. In this context, as it has already been explained before, technology foresight studies serve as perfect tools in including the concerned parties and strata of the society into this policy design process. Vision 2003 foresight study is expected to set a good example in this regard. According to this project, Turkey should focus on four areas which are; enhancing the competitiveness of the Turkish industry; improving the quality of life of Turkish citizen; sustainable development in Turkey; strengthening the technological infrastructure in order to accelerate transition to a knowledge-based society.

On the other side, Vision 2003 Project still proceeds, leaving us without the opportunity to discuss the results of an enduring project. However, such a study is expected to contribute to Turkey's catching up with the change of era in technology sourcing the evolution process to the information society by eliminating her historical deficiency due her not having overcome the industrialisation threshold as mentioned in the previous pages. However, in capitalist economies, at the level of technology ' creation' , technological innovation is not only impelled by scientific discovery, but is also induced by demand. The development of a potential economic idea into new products and processes requires many stages of experimentation. In addition, its acceptability is related social attitudes, standards, cultural norms and politics. So that the creation of technological capabilities, in other words, science and technology should not be limited to the economic integration of technological change, but must include all aspects of the broader social integration of such change. In this context, it can be said that today the superiority of countries in science and technology is the main determinant factor of increasing the welfare of society. Furthermore, under these conditions, if any country -e.g. Turkey- wants to increase its share in the world's resources it should improve its scientific and technological ability. However, gaining ability in science and technology does not only mean the same in scientific and technological research, but also it denotes that a nation can gain competitive advantage in the world market if only she can achieve to establish a systematically operating National Innovation System.

In conclusion, today there are increasing attempts to integrate science and technology policies with policies on industry and economy. There are many reasons that can be used for this change, in short; on the one side, the pressures of the marketplace, of competition and of profitability compelled many firms to review their R&D projects and programs much more critically. On other side, also governments have been imposed to strong pressures in the same direction, huge expansion carried with it the demand for greater public accountability; many studies pointed to the great importance of other scientific and technical activities, as well as R&D in the industrial innovation process. These critiques also brought about the new questions like whether there is a way, which provide sustained development and economic growth in the long term.

CHAPTER V

5. CONCLUSION

Despite the economic fluctuations that spread across the OECD countries in investment and exploitation of knowledge remain key driving forces of innovation, economic performance, and social well-being. Over the last decade, investments in knowledge, as measured by expenditures on R&D, higher education, and ICTs–grew more rapidly than the expectations. The movement of developed countries towards a knowledge-based society is linked to the emergence of a more networked economy, which has helped to improve productivity, chiefly through the generation, diffusion, and use of information. ICTs in particular have played a key role in the increase in labour productivity in several developed countries for the 1990s and boosted labour productivity. The widespread adoption of ICTs has led to new modes of work organisation, which enhance the benefits that these technologies offer for disseminating and using information. The shift towards a more networked economy has been accompanied by and facilitated tighter integration of the knowledge economy and an expansion of market and non-market transactions of knowledge. The production and application of scientific and technological knowledge has become a more collective effort, linking the activities of industry, academia, and government. Formal and informal co-operation among institutions has become crucial for reaping the full benefits of knowledge creation and fostering the development of new technological innovations. All forms of collaboration, including co-operative research, public/private partnerships, international and domestic strategic alliances, and foreign direct investment, have been increasing.

Furthermore, after stagnating in the first part of the 1990s, developed countries as a whole devote more resources to R&D, for instance OECD-wide R&D investments grew in real terms from USD 416 billion to USD 552 billion between 1994 and 2000, which resulted almost exclusively from increases in industry-financed R&D, and R&D intensity climbed from 2.04% to 2.24% of GDP (OECD, 2002). On the other hand, countries that posted the largest percentage point gains in R&D

intensity tended to be those with already high levels of R&D, such as Finland and Sweden, further widening the gap between them and less R&D-intensive countries, such as Poland, Hungary, the Slovak Republic, and Turkey. Growing emphasis is placed on the productivity, enhancing role of human capital and higher education systems, which are central to the creation, dissemination, and utilisation of S&T knowledge. Thus, science, technology, and innovation remain central to economic growth in developed countries.

OECD governments are paying more attention to the contribution of science and innovation to economic growth and have introduced a variety of new initiatives and reforms such as Ireland, Korea, and Turkey etc. In a number of countries, government institutions and agencies have been restructured in an attempt to improve the governance of innovation systems, and policy evaluation has become more widespread. Public research systems are being reformed to better contribute to economic and social needs and new applications on promotion of innovative networks and clusters, creation of centres of excellence, and greater use of public/private partnerships for innovation have been developed. Many governments have introduced initiatives to support research in SMEs and facilitate the commercialisation of public research through spin-offs. Traditional public missions such as health, defence, and environmental protection remain major areas for public funding of R&D, but most OECD governments have also identified priorities in specific fields of science and technology. In general, these involve enabling technologies that address a number of social objectives and are of value to fast-growing industrial sectors. ICTs and biotechnology have received special attention in most OECD countries, with nanotechnology also attracting considerable support. Thus, developed countries governments have been adapting policy frameworks to enhance the contribution of science, technology, and innovation to their economic growth.

Changes in the business environment; technological change, competition, and globalisation, are motivating a restructuring of business R&D processes and strategies. Increasing competition has shortened product lifecycles in many industries, and scientific & technological advances have opened up new business opportunities. In response, firms are linking their R&D programmes more closely to their business needs and taking greater advantage of technologies developed in other firms and in universities and government research labs. In line with the trend towards outsourcing R&D, firms are increasingly developing their market technologies internally. By licensing technology to other firms or establishing spinout firms to bring the technology to market, they are able to generate value and revenues as well, from technology, which may encourage firms to invest in more broad-based R&D programmes. As knowledge-intensive sectors continue to expand and competitive pressures grow, government financing of basic research will become a more central element of support to business R&D. The direct forms of government support for business R&D, such as tax incentives, grants, loans, government financing and also support for R&D in SMEs will remain an important element of the developed countries policy implementations. Successful promotion of business R&D entails promoting networking and interaction among firms and between the public and private sectors, ensuring adequate IPRs. Thus, government policies have developed to stimulate innovation by regarding changing patterns of business R&D implications.

As with the contributions of basic scientific and technological research to innovation, economic growth and other social objectives become clearer and constraints on government budgets for public research grow, governments are seeking greater efficiency and accountability in public R&D spending. Governments in most developed countries are taking steps to reshape and improve the governance of public research systems comprised of universities and other public research organisations, notably as regards mechanisms to define research priorities and allocate funding to projects and institutions. Numerous reforms have been introduced to increase the social and economic returns from public research without sacrificing their ability to ability to explore fundamental scientific and technical phenomena, disseminate knowledge broadly, and address research problems beyond those of immediate commercial interest. Several countries have established new priority setting mechanisms that include formalised foresight exercises and increased involvement of industry and other stakeholders. Centres of excellence have been established to bring together researchers from different disciplines to tackle problems of common interest. Thus, governments in most developed countries are taking steps to reshape and improve the governance of public research systems.

Market liberalisation, regulatory reform, technological changes, and the specialisation of firms spurred a wave of industrial globalisation and restructuring in the 1990s. The number of domestic and international strategic alliances also grew during the 1990s. Growth took place not only between manufacturing firms but also in greater number of firms in the service sector. The expansion of multinational corporations and the growing number of alliances are changing the way science and technology activities are undertaken. International trade in highly R&D-intensive industries also increased rapidly in the developed countries area throughout the 1990s. Government policies also influence the ability of firms to restructure themselves via international area and strategic alliances, as well as the distribution of the costs and benefits of such activities. Reductions in corporate and capital gains taxes can also be used to attract foreign investment, by lowering the cost of entering the market. Efforts to develop local science and technology capabilities have also proven effective in attracting R&D investments. Thus, globalisation has been driving industrial restructuring and changing the way research and innovation takes place.

Under these circumstances, it would not be a much of exaggeration if I state in this text that we are witnessing today a 'historical phenomenon' as considered by some, that I would describe as a new industrial revolution, with respect to its social, political, and economic impacts, which are discussed in Chapter III. In short, this concept is distinguished mostly by the radical changes in the technology base of the production systems and labour process. The developments in ICT and the application of these developments in the production and design of goods and services make fundamental changes on these processes. Globalisation has been progressing concurrently with the revolutionary changes highlighted above. Besides, globalisation does not necessarily and always decrease the importance of the national development, on the contrary, it can increase its importance, and also the national innovation policies are moving to a different field, becoming more complex and multi-dimensional, as well as the concept of 'industrialisation' acquires a new content with knowledge and technology. More clearly, how the specific conditions of the globalisation process can be transformed into national advantage is main problem for the developing countries.

Today, technology is transferred when it is old enough to transfer, and can be traded in this way. Not all the technology production and utilisation is allowed for all fields. The transfer of sensitive technologies is under control, including outstanding constraints. The other important features of knowledge and technology can be outlined as; *firstly*, knowledge and technology are not free commodities, they have a certain cost, and technology in particular, is rather expensive. In fact, technology occupies a large portion in all new goods and services put forward as advanced technology product; this portion increases up to 80% in sophisticated products. *Secondly*, the developed technology does not expire when used; the same technology can be sold to a number of countries and industrial establishments in change of a certain cost. *Thirdly*, each development in the field of technology prepares the next; thus, technology has cumulative characteristics, like a snowball. When a technological system of positive feedback is set up, a continual development and growth are attained. *Fourthly*, technology has a life cycle, which emerges, develops, ripens, and grows old. In the introduction of newer technologies and the capacity of foreseeing/estimating the future developments, the science, technology, and innovation system of the country play the vital role; and *besides*, the knowledge and technologies developed within a country is limited compared to those generated in the whole world. Therefore, each country should apply to technology transfer as well. However, the countries and firms that keep their STI expenditures under the critical value, that do not have a future vision and that do not produce technology, pay a cost of ignorance, generally due to selecting the inappropriate technologies. As a result, today dominant policy put into practice denotes that: technology transfer in a number of fields will be harder and it will consequently become impossible to purchase new technologies. In other words, it will not be possible for a country that lacks a sound S&T system to compete with a developed industrial country.

On the other side, Turkey, as a country that could not pass over the industrialisation threshold has to cover up this historical deficiency of hers, and catch up with the changing era in technology, which sources the evolution process of the information society. Amongst the threats and opportunities created by the 'globalisation' period, Turkey is in the search of its self-survival, which is located in the midst of a political geography dominated by a 'low intensity war' climate in the Balkans, Middle East, and Caucasus. Under these circumstances, Turkey requires to define an acceptable and attainable future for herself and realise that purpose. It is evident that there is no future identifiable for a Turkey, which cannot dare become competent in technology and innovation and cannot find the ways in which she could achieve this prospect. At the macro/theoretical level, the new expectations/role of Turkish government could be summarised, in accord with discussions throughout the thesis, under the five main headings, analysed below.

In the area of e*mbodiment of innovation culture,* the government role is obviously limited, which can be resulted from inappropriate work organisation, poor management practices, underdeveloped techniques etc. However, government can support where market shortcomings or the system hinder adoption of best practices. Such support would be very meaningful when the infrastructure gaps and information asymmetries exist, or can also be in the form of more direct facilitators/catalyses of innovative firm behaviour through policy initiatives that encourage flexible management structures, organisational change, and training. Moreover, governments can promote management improvement programs such as strategic planning, staff training etc., which promote innovation culture, and they can pay special attention to new technology-based projects/firms via raising obstacles to their transformation into business start-ups, removing regulatory barriers to entry when appropriate, encouraging the development of private venture capital, reforming regulations which unduly inhibit entrepreneurship on the part of researchers in the public and private sectors, removing other obstacles to risk taking, e.g. bankruptcy.

In the area of *diffusion of new technologies,* government should pay direct attention towards a wide range of firms, from the technologically advanced firms to firms in traditional sectors. In order to increase diffusion, government can; improve the performance of different channels such as information networks, demonstration and benchmarking schemes, and technical assistance etc. in order to increase dissemination of technology; facilitate firms to access and exploit new technologies via designing and integrating public schemes; upgrade its education policy which should emphasise multidisciplinary and lifelong learning and should focus on new skill requirements such as networking, maintaining interpersonal relationships, communicating effectively etc., and adapting to change, and focus on incentives for worker training and on easing the mobility of personnel within and between the public and private sectors.

In the area of *encouragement of networking and clustering,* government policies should focus on increasing firm ability to interact with other firms and organisations rather than take them as an isolated structure. In this framework, government can re-regulate competition laws and regulations in order remove unnecessary barriers to co-operation, alliances and networks; can improve links between knowledge-intensive services and firms in for improving their organisational and technical transformation; can support interaction between public research infrastructure with less actively collaborating actors, of system e.g. SMEs; can rearrange its policies for focusing R&D schemes, innovative public procurement, investment incentives and the creation of 'centres of excellence'

In the area of *increasing R&D activities and reinforcement of relationships between university and industry*, government policies should provide the balance between continuity of curiosity-driven research and help the science system adjust to the emerging entrepreneurial model of knowledge generation and use. For this aim, government can give guarantee on funding for long-term research in universities, publicly funded laboratories/institutes for getting more benefits in long-term research activities; can create more flexible funding arrangements, e.g. contract-based resources, strengthen university/industry co-operation in research, and heighten mobility of university/ government researchers; increase the efficiency of existing financial support programmes; foster commercialisation of research activities, by including through patents, via providing institutional flexibility and appropriate intellectual property rights rules and other regulations.

In the area of *succeed to globalisation,* government policies should increase country's ability to absorb science and technology from around the world and make themselves attractive locations for innovation. For increasing absorptive and innovative capacity, government can; improve indigenous technology base and strengthen the links within national economies to obtain spillovers from research; create 'centre of excellence' for attracting foreign R&D investments and personnel; and enhance international co-operation in R&D.

At the micro/practical level, as mentioned previously, it is important on the supply side of technology to introduce public policies and corporate strategies that developed sufficient technology capability to undertake imitative reverse engineering of mature foreign products without infringing intellectual property rights. On the demand side of technology, it is imperative to introduce market competition in order to expedite technological learning. In accordance with these two claims, the ways that Turkey should follow are analysed below.

The first and foremost implication for public policy should be expending investment in education, although building a significant number of educational institutions requires enormous financial and intellectual investment. It is clear that the expansion of education will be more rapidly than the economic development, and will create a short-term unemployment problem as well; the number of graduates in most fields will exceed demand. Consequently, unemployment among the educated will be regarded as a serious social problem in the following years. But the formation of educated human resources lain an important foundation for the subsequent development in the economy, which soon absorb the surplus.

Under the World Trade Organisation regime, it is not easy to restrict the flow of foreign technology or investment. Nevertheless, it is important for Turkey, to recognise that in the early stage of industrialisation, FL (Foreign Licence) and FDI (Foreign Direct Investment) are not important mechanisms for acquiring technologies. Rather, the procurement of turnkey plants and capital goods can be more effective means in this regard. Turkey should restrict FL and FDI but promote instead technology transfer through other means, such as capital goods imports in the early years. Capital can be acquired in the form of foreign loans. Such a policy, designed to maintain Turkey's management independence from foreign multinationals, would be effective in forcing Turkish firms to take initiative and a central role in learning (i.e. acquiring, assimilating and improving improved technologies), rather than relying entirely on foreign sources. Well-trained and educated staffs might be motivated to maximise technological learning from readily available foreign goods, and might be equipped with sufficient tacit knowledge to reverse engineer them successfully. Furthermore, the best way to use FL as a means to expedite technological learning is unpackaging it. FL in a 'packaged' form from a single source involves little risk to the technology recipient, as the performance of the transferred technology is guaranteed by the supplier. However, it leads to a passive attitude on the part of the recipient in the learning process. In contrast, when unpackaging technologies, the recipient acquires them from multiple sources, and takes the responsibility to integrate them into a workable system, it entails a major risk. This constructs a crisis, and consequently forces and motivates the recipient to expedite technological learning. When the recipient has adequate tacit knowledge, it is better to take responsibility to integrate technologies to expedite learning. Therefore, foreign technology transfer can provide new dimensions in raising the knowledge level and can serve as a catalytic source of technological change, enabling firms to make a quantum jump in indigenous technological learning.

In addition, it is an imperative for Turkey to adopt export promotion policy if she wants to expedite industrialisation. This policy creates business opportunities and concurrently imposes crises for firms to undergo 'a life or death' struggle in the competitive international market. The past crises of Turkey experience shows that, to survive in the crises, Turkish firms had to accelerate learning by importing and rapidly assimilating production technology from abroad. As the export promotion policies continually place pressure on firms to sustain competitiveness in the changing international technology and market environment, export-oriented firms acquires more foreign technologies than import substituting firms. Consequently, the export-oriented industries will have been accounted for the majority of licensing and capital goods imports in Turkey. Furthermore, restriction on FDI will force firms to take an independent approach to assimilating imported technology, which will provoke firms to accelerate learning. As a result, firms in export-oriented industries will learn significantly more rapidly, and in turn, grow faster than firms in import-substituting industries.

Moreover, it is important to invest in developing S&T infrastructure such as government research institutes in the early stage of industrialisation, although it takes a decade or longer to develop an effective S&T infrastructure. It is obvious that in the early stage of industrialisation, S&T infrastructure, particularly government research institutions, suffers from poor linkages with industries. Furthermore, researchers might not compete with foreign licensors in supplying detailed blueprints and other manufacturing know-how. They might be unable to assist industries in solving teething problems in the crucial initial stage. The most important role of S&T infrastructure in the early stage, albeit unintended, will to generate experienced researchers when the private sector falters in R&D investment. Then when large firms will begin establishing corporate R&D centres to respond to market competition, these experienced researchers can spin out of the S&T infrastructure and play a pivotal role in these private R&D centres.

It is also necessary to adapt a liberal policy on brain drain in the long-run, allowing scarce scientists and engineers to migrate to advanced countries. Otherwise, many of them will not find suitable jobs and continue to advance their technical competence at home in the early stages of industrialisation. These people might not only strengthen the bargaining power in technology transfer and to assimilate increasingly complex technologies but also become important sources of an outside technical network and a high-calibre manpower pool for Turkey's subsequent development.

As we have already underlined, there is an advantage in establishing a separate ministry of S&T in the government to focus solely on S&T issues for the future, when action-oriented ministries are not all interested in preparation for industrialisation from a long-term perspective. This ministry can make major contributions to establishing S&T infrastructure and promoting public R&D activities to pave the way for subsequent entry by the private sector. The separate ministry, however, is not necessarily the best way in the later stage of industrialisation, when technology becomes an important issue in other action-oriented ministries. Some experiences of OECD countries indicate that the separate ministry of science and technology is not an appropriate position to bring about effective coordination across government ministries, suggesting that government restructuring is in order as industrialisation progress. However, it is extremely difficult to restructure government organisation due to bureaucratic rigidity and inertia.

Another important point for governments in Turkey is to foster entrepreneurs. Turkey has a sufficient resourcing of component economists, scientists and engineers, and has enough literate workforce to promote industrialisation programmes. Capital and technology may be acquired from abroad. What Turkey lacks at some point are the entrepreneurs, who could bring these resources together and manage them effectively to generate wealth by meeting existing and potential market needs. The government can privatise state-owned enterprises to selected local entrepreneurs of favourable terms to help these from necessary capital. The government then manages these entrepreneurs relatively effectively by penalising poor performance and rewarding only good ones. Good performers could be rewarded with further licenses to expand. The government might also encourage these entrepreneurs to enter risky businesses by matching industrial licences in more lucrative sectors.

On the one hand, for small and medium-sized enterprises that have neither the financial resources nor the organisational capability to identify and negotiate collaborative agreements with foreign suppliers, the least expensive and but effective way to tackle mature technology is to take an imitative approach by developing the capability to make sense of blueprints, manuals, technical specifications and machinery which are readily available. Such capability may be acquired most effectively by poaching experienced personnel from existing large firms. In this way, the most of the innovative SMEs might be invaded the mature industry in this manner. On the other hand, for large firms that have the financial and organisational capability to negotiate with foreign suppliers, the most effective way to tackle a large-scale mature technology is to enter collaborative agreements with foreign suppliers. Given the scale of large investment required and the lack of technological capability and experience in the early years, it is better for large local firms to look to experienced foreign firms to ensure swift construction and smooth start-up of their production processes, and to acquire technical information and training to manufacture goods with stringent specifications. Therefore, it is important to develop a balanced industrial structure. If Turkey has only advantage, that is the strength of its big business or if Turkey has only advantage is the strength of its SMEs, those advantages, however, bore weakness on the other side. The first causes lack strong support of dynamic SMEs to make large-scale assemblers innovative, which results with Turkey large firms dependency on foreign country SMEs to supply critical components. In contrast, the second causes lack large firms to challenge scale-intensive industries. As a result Turkey on the one hand should deliberately promote the formation and growth of large firms in order to bring about scale economy in the labour-intensive high industries, on the other hand Turkey deliberately keep large business for mentioned reason in order to provide industrial structure to sustain a healthy growth.

Lastly, informal mechanisms are more important than formal mechanisms in acquiring foreign technologies. Turkish firms can benefit greatly from informal technology transfer. This mode of technology transfer has clearly prevailed in innovative small firms and for a long time it has been significantly broadening the capabilities of all exporters. The majority of important or crucial information needed to solve technical problems in the early years of industrialisation can be obtained free of change through non-market mediated informal mechanisms, however, it is imperative to exert in-house assimilation efforts to acquire indigenous capability. Such capability will enable them to reverse engineer readily available mature, general technologies, to strengthen bargaining power against foreign technology suppliers in technology transfer negotiation and to expedite the assimilation of imported technologies. Consequently, neither the firm that related solely on foreign technological inputs, nor the one that relied exclusively on its own technological efforts would be technologically most dynamic but the firms, which can combine both, would be successful.

Therefore, this text started with stating the essential historical background and major definitions, concepts and methods regarding STI in the world, followed up with an in depth analysis of the case of Turkey in order to locate its place in the world with respect to policy-making and implementation processes with 5-year development plans and other tools/researches. The determinative role of increasing productivity is pointed in gaining competitive advantage in the world markets. Later, it is tried to be demonstrated the fact that it is possible only through acquiring innovation capabilities; and the principles for attaining this capability have been put forward. In this context, the issue of ‘innovation policy’ of Turkey has been analysed, together with its basic motive, the concept of ‘national innovation system’. It has been suggested that sufficient success could not be achieved in this regard, as there is a systemic failure. Then, the reasons for this failure have been analysed, particularly the role of industry and political/bureaucratic cadres have been investigated; mentioning the other studies implemented on this subject. Finally, the suggestions, which Turkey should implement, were discussed.

The basic reason should be emphasised for the failure in science and technology policy designs put forth since 1960s, which lead in science and technology matters not to take place in the political agenda as required. That is, in order an issue to take place in the political agenda, there should be a strong societal demand supporting that subject. However, Turkish economy became increasingly detached from a production-focused approach. The demand for science and technology, on the contrary, can only be created in productive economies. It is understood that unless the appropriate climate is provided encouraging transition from rent economy to production economy, and stimulating a tendency towards investments particularly by the industry into the direction of production, the demand for science and technology will remain limited. In consequence, S&T policies will not achieve to go beyond an area, which, some groups conscious of their responsibilities try to carve a niche into the history.

As a result, it is revealed again the fact that it is not possible to define a future in the world markets and any other area for a Turkey that cannot improve its science, technology, and innovation capabilities. This failure in STI capability will eventually lead Turkey to lose in all means. Turkey should implement right policies in attaining competence and capabilities in world market. In addition, what I consider more important than that is the assuming of executive authorities, political/ bureaucratic cadres and governments their role in the implementation of STI and R&D, to provide a sustainable and effectively working system. Lastly, If we take our own science and technology management and national innovation management systems in this integrity, I believe that we can find many innovation opportunities that will enable us ‘a quantum jump’ in national productivity and, as a result, in international competitive advantage.

APPENDICES

APPENDIX A

Eighth Five-Year Development Plan

Under the title of "Developments in the World and Turkey", the process of globalization, knowledge economy and knowledge society are evaluated.

- The globalization process that started with the liberalization movements in the financial markets in late 1970s and developments in the communication technology, speeded up with liberalization in foreign trade and developments in the technological progress which has gained impetus and influenced all the other fields in economy, has started to become a determining factor in the social and cultural fields in recent years. (Ariticle 1);
- Simpler and faster long distance dissemination of information as a result of rapid developments in computer and informatics has played an important role in the globalization of supply and thus, of competition among firms. This process has led to radical changes in the international competition rules (Ariticle 2);
- Both the progress in informatics and microelectronic technology and concomitant technical advancements in telecommunications sector played major roles in the globalization of production. The firms with the ability to transfer a large amount of information to remote places at lower costs gained the opportunity to organize diverse stages of production in various geographical areas without any loss in management efficiency. These developments together with advancements in biotechnology-genetics engineering and new material lead to an acceleration in building up information economy and society (Ariticle 4);
- Progress in technology enabled substitution of not only simple labour power but also brainpower to a certain extent, thus knowledge-based production has gained great impetus leading to stable increases in technological innovation and efficiency (Article 6);

- Since knowledge is the most important production factor in building up information society, improvement of the labour force quality and establishment of developed communication infrastructure gains importance. So, the biggest contribution to the development in the 21^{st} century shall be through investments in human resources and improvement of the infrastructure (Article 7);
- Countries adapting themselves to the rapid change in the world, furnishing their citizens with the capabilities required by this new medium, having access to, producing and using information shall be effective and successful in the 21^{st} century (Articile 18);
- Strengthening its social structure, ensuring stability, completing structural reforms and realizing basic transformations required by the information society, besides benefiting at the highest level from the opportunities created by globalization and minimizing its unfavourable aspects, shall also play a key role in preparing Turkey for the future and in attaining a more effective status within the world (Article 19).

The general assessment of science and technology area was taken place as following;

- As of 1997, the ratio of GERD to GDP was 0.49 percent, and the number of R&D personnel (full time equivalent) and researchers Per ten thousand labour force were 10.4 and 8.2 respectively (Article 145);
- Although it was envisaged in the 7^{th} Plan, sufficient resources could not be allocated to R&D activities and the number of researchers could not be increased (Article 146);
- The need for harmonization between the science-technology-industry policies and education-training and R&D policies persists (Article 147).

The determinations in the informatics technology are;

- The awareness about informatics technology has risen, and thus with the cooperation of the universities, public and private sectors, opportunities were created towards formulating and implementing more efficient and realistic policies concerning the sector (Article 148);
- The National Information Infrastructure Master Plan (TUENA) adopted by the Science and Technology Supreme Council and implemented by the Ministry of Transport were concluded, however, studies concerning the organizations envisaged in the Master Plan could not be started (Article 149).

In the part of Basıc Targets And Strategy For Long-Term Development (2001-2023);

- Strengthening scientific and technological capacity (Article 162);
- An export-oriented, technology-intensive production structure with an emphasis on generating a high value added, consistent with the international standards and which would activate local resources is targeted (Article 163);
- Public investments are planned to be intensified in the fields of education, health and R&D during the 2001-23 period (Article 177).

In the part of Basic Targets, Principles and Policies of the Plan;

- Turkish industrialization policy aims a flexible structure in which it will enhance technology, with an emphasis on R&D also meeting the environmental norms, respecting consumer health and preferences, activating local resources, utilizing qualified labour power, implementing contemporary management and production methods for taking advantage of the globalization with an ability to make original designs, create trade marks, and shift to knowledge-and technology-intensive fields (Article 189);
- To expand the use of knowledge through access to knowledge at national and international levels, necessary legal and institutional arrangements shall be made and information and communication technology infrastructure shall be rapidly developed (Article 192).

Policy and targets in the science and technology is discussed under the title of "Development Objectives and Policies Related to Social and Economic Sectors". Firstly, the current situation of science and technology and targets, which were determined but could not be achieved in the period of the VII Development Plan are summarized;

- The advancements in science and technology achieved within the 7th Plan period remained below the desired level. Despite it was envisaged in the Plan, sufficient resources could not be set aside for R&D activities and the number of research staff could not be increased (Article 1190);
- As of 1997, the ratio of Gross Domestic Expenditure on Research and Development (GERD) to Gross Domestic Production (GDP) was 0.49 percent, the number of R&D personnel (full-time equivalent) per ten thousand labour force and researchers were 10,4 and 8,2 respectively (Article 1191);

- The need to establish harmonization between policies set up for science-technology-industry and those for education-training and R&D still persists (Article 1192);
- Important steps have been taken towards establishing a national R&D network, comprising public and private R&D institutions as well as universities while a National Academic Network has been established (Article 1193);
- The physical infrastructure required for the betterment of employment and working conditions of R&D personnel could not be developed efficiently and necessary arrangements in the legislation could not be made (Article 1194);
- Works on harmonizing the Defense Supply Systems based on R&D with the purchasing policy of the state, aiming at improving the national defense industry, are being carried on (Article 1195);
- Law on the Establishment and duties of the Turkish Accreditation Institute (TÜRKAK) has been enacted (Article 1196);
- Venture capital implementations aimed at converting technological knowledge obtained from R&D activities into commercial goods could not be realized (Article 1197);
- With the DHFL (Decree Having The Force of Law) No 544, the Turkish Patent Institute has been established, with DHFL No 551 patent rights, with DHFL No 554 industrial designs, with DHFL No 555 geographic signs and with DHFL No 556 trade marks have been given protection. Notification on Subsidizing Registration Expenses of Patents, Utility Model Certificates and Industrial Designs has been published (Article 1198).

In addition, the objectives, principles, policies and the legal and institutional arrangements of the plan are pointed out in the same chapter.

- The main objective is to achieve competitiveness at international level by scientific and technological developments (Article, 1199);
- In order to enhance the scientific and technological researches level the required physical, human and legal infrastructure shall be restored. It is targeted to raise the proportion of GDP, set aside for R&D activities to 1.5 percent and to increase the number of the full time equivalent R&D personnel per 10 thousand economically active people to 20, until the end of the plan period (Article 1200);
- Action Plans shall be devised by taking into account current studies on transition to information economy and society (Article 1217);
- The National Innovation System shall be completed and efficiently operated (Article 1202);

- Legal and institutional arrangements required for the smooth functioning of the National Innovation System shall be made (Article 1228);
- Manpower shall be considered as a strategic resource whereby education policies shall be geared to adjusting to constantly changing technologies, training manpower with trouble shooting abilities and creative qualities (Artcile 1203);
- Duties of higher education institutions shall be re-determined and attention shall be paid to an equipment infrastructure at international standards (Article 1204);
- Necessary arrangements in the legislation shall be made in order to meet the deficit in the number R&D personnel and to make work of research attractive (Article 1223);
- At each level of education, scientific and technological activities that motivate the intelligence and that give priority on creativity shall be encouraged (Article 1209);
- Science and Technology Centres that will have supporting impacts on formal education, aiming at approximating the society by science and technology shall be established and developed (Article 1208);
- Joint R&D activities within a university-public-private sector cooperation shall be encouraged and supported (Article 1206);
- The essentials of the university-industry cooperation shall be arranged (Article 1221);
- The scope of the current legislation on state aids granted to R&D will be extended (Article 1220);
- The purchasing policy of the state shall be oriented towards improving the scientific, technological and industrial potential of the country (Article 1212);
- In the field of planning and meeting the requirements of the national defense industry, the technological capacity of the country shall be utilized at the greatest extent (Article1211);
- Necessary arrangements in the public procurement policies and in the Law No 2886 shall be made in order to enable domestic supply based on R&D (Article 1219);
- The venture capital implementation in the field of converting technological knowledge obtained from R&D activities into tradable goods, shall be further improved and applied widespread (Article 1213);
- Legal arrangements shall be made, aiming at encouraging the establishment of venture capital investment partnerships (Article 1218);

- Technological cooperation opportunities with EU shall be utilized at the utmost level.(Artcile1216);
- Direct foreign capital investments contributing to technological development, shall be encouraged (Article 1215);
- Local information networks shall be improved and integrated with international network structures (Article 1201);
- R&D activities in the fields of advanced applications such as, information and communication technologies, new materials, aerospace and space technologies, nuclear technologies, oceanography, technologies on utilizing and exploiting sea and underwater riches, mega science and clean energy technologies, whereby the fields of biotechnology, gene engineering, and software have predominance, shall be supported (Article 1207);
- The establishment of Industrial Parks in the advanced technology fields shall be supported (Article 1214);
- Legal arrangements on the establishment of a Turkish Metrology Institute shall be made (Article 1224);
- A National Aviation and Space Organization will be established in order to provide coordination among activities in the field of aviation and space (Article 1226);
- A High Biotechnology Council will be established (Article 1227);

Beyond these general explanations of scientific and technological aims and targets, there are many principles and targets, which are related to the investigated social and economic sectors' technology development.

<u>Education and Manpower:</u>

- Satisfactory developments in utilization and extension of new technologies in education could not have been ensured. Initiating computerized education at all levels of education, providing internet access for every school and producing curriculum as software programs bear great importance (Article 661);
- Programs shall be developed for the purpose of equipping teachers and students with technological literacy within education process (Article 770).

<u>Employment:</u>

- The employment creating potential of the Small and Medium-Size Enterprises that bear importance in increasing employment and that back up the development of the industrial sector by providing input, shall be utilized at utmost level. For that reason, support of Small and Medium-Size Enterprises and individual undertakings shall be increased by contributions in the fields of education, projects, financing, organization, marketing and technology (Article 933);

- In order to prevent brain drain, measures shall be taken to employ and keep qualified manpower within the country (Article 934);
- The development potential of employment shall be enhanced by upgrading labour force quality within the framework of harmonization with the EU and in line with technological developments (Article 939).

Mining:

- Furthermore, works on determining crude oil and natural gas potential in our seas by using new technologies shall be carried on (Article 1104);
- Studies, on distinguishing geological and geo-physical peculiarities of the seas in Turkey that are included in the National Maritime Geology and Geo-Physics Project shall be carried on within the Plan period (Article 1105).

Manufacturing Industry:

- The industrial sector shall be given a structure, produce in compliance with the environmental norms, use high quality labour, apply a modern management approach, give importance to R&D, generate technology, create original designs and trademarks and thus take its place within international markets (Article 1135);
- Developing information and technology intense industries in the fields of defense and aviation, machinery, chemistry electronics and software industry, ensuring prevalent use of advanced technologies in industry (Article 1137);
- In order to enhance the technological potential of industry, efforts will be made to provide the support for university-industry collaboration within integration, for the establishment of technological back up and improvement centres, new technoparks and for technology institutes. Furthermore, increase in R&D supports shall be provided (Article 1138);
- Considering the manufacturing industry, supporting investments on R&D, whereby information and communication technologies take the first place, innovative production and technology generation, shall be further pursued (Article 1140);
- The national quality infrastructure shall be completed and the Turkish Accreditation Institute shall be made operational as soon as possible to ensure

the enhancement of the competitiveness of industry and the free movement of Turkish goods in the EU market (Article 1141);

- Considering the defense industry, it is envisaged to enhance domestic production within a structure that is open to competition having export generating potential and integrated with the industry of the country. Furthermore it is envisaged to set up the necessary technological base for the realization of these issues (Article 1145);
- By enhancing supports on developing new products having high value added generating capacity in the fields having priority, it will be enabled that the electronics and software sectors gain a greater share from the global markets (Article 1153).

<u>Development of SMEs:</u>

- The SMEs shall be oriented towards R&D activities and their collaboration with Universities within technoparks will be ensured (Article 1184);
- Arrangements, providing the improvement of the risk capital system shall be made (Article 1189).

<u>ICT:</u>

- R&D activities in the field of information technologies will be supported (Article 1244);
- In the field of information and communication technologies, legal, administrative and technical arrangements that shall ease the access to the services provided by technological developments and the convergence of the sub-sectors shall be concluded rapidly (Article 1246);
- National policies will be formulated, in order to ensure the development of internet services. Legal and technical arrangements shall be made so as to enable the utilization of alternative infrastructures to be established by the private sector (Article 1253);
- Establishing the necessary technical and legal infrastructure (Article 1254);
- The information and communication technologies infrastructure of universities, and national and international network connections shall be enhanced (Article 1258).

Agricultural Development:

- Agricultural research organizations shall be given an efficient structure. Coordination among research activities, carried out by various institutions, establishments and universities, shall be ensured (Article 1288);
- In setting the priorities in the field of agricultural research, farmers' demands shall be taken into account and in developing and implementing applied research projects (Article 1289);
- In order to increase sustainable production in fishery products, importance shall be attached to research and improvement activities. Besides, necessary arrangements shall be made in order to establish an effective institutional structure in the public sector (Article 1299).

Energy:

- Measures shall be taken towards developing and spreading new and renewable energy sources (Article 1436);
- Importance shall be attached to long-term nuclear energy development plans (Article 1437).

Environment:

- Environmentally friendly technologies shall be given priority in determination of industrial policies and new industrial investments. Local manufacturers shall be informed about these and encouraged to use them (Article 1819);
- In order to minimize bio-safety risks, which may result from biotechnological practices, legal, institutional and practical arrangements shall be made with a holistic approach (Article 1821);
- Law on Bio-safety shall be enacted and a National Bio-safety Board shall be established (Article 1825).

APPENDIX B

Analysis of Science and Technology Policy of Turkey: 1993-2003

Decision (1.a): The number of full-time (or similar) R&D personnel, which is 7 per 10.000 working population, to be increased up to more than 15...

Result: The number of R&D personnel per 10.000 working population, increased from 7.5 (1990) to 13.1 in 2000.

Decision (1.b): The proportion of the R&D expenditure from the national GDP should be increased from 0.33% to more than 1%...

Result: The proportion of R&D expenses / GDP, which was 32.0% in 1990, have risen up to 0.53% in 1991, and decreased to 0.36% in 1993. It could attain only 0.64% in 2000.

Decision (1.c): The grade of Turkey in the world regarding her contribution to universal science and technology should be raised from 40th to 30th...

Result: According to the scoring made based on the country addresses of the natural sciences articles in the Science Citation Index, Turkey raised its score from 41st as she was in the end of 1980s, to 22nd in 2002 with 9303 articles, the number of which increased particularly after 1995.

Decision (1.d): The portion of private sector expenses on the country's research and development activities should be increased from the existing 18% to 30%...

Result: When the total R&D expenditure is analysed within the sectors involved in R&D, this portion has been 28.4%, 35%, and 30% in years 1998, 1999, and 2000, respectively.

Decision (2): In order to reach the targets denoted in Decision (1), considering the existing potential in our country and the direction of science and technology in the world, it has been decided that priority will be given to the subjects stated below; which affect all sectors of the economy and almost the entire living areas:

- Informatics (combination of computer, microelectronics, and telecommunication technologies)
- Advanced technology materials
- Biotechnology
- Nuclear Technology
- Space Technology

The policy document prepared on the informatics sector has been approved by the council. According to this document, in order Turkey to take the maximum advantage out of informatics;

- Human resource should be improved
- Informatics technologies should be familiarised with the pioneering of the public sector
- The appropriate legal arrangements should be done,
- The research and development studies on informatics technologies should be developed and their targets should be set.

It is also accepted similar policy documents to be prepared on other areas by the concerned institutions and presented to the council.

Result: The implementation of these decisions is concerned with a number of policy fields ranging from education to infrastructural policies. On the other side, there could not be achieved any significant developments regarding the issue of building up proficiency in the above mentioned prioritised fields; informatics, advanced technology materials, biotechnology, nuclear technology, and space technology. The basic reason for this is unfortunately the mentioned decisions have not been assumed by the political authority and this application could not be handled in a sustainable and systemic integrity.

Area of Development I:

The establishment of the National Information Network and Telematics Services Network that could be served by the former

Result: The basic purpose, which is also the distinctive character of the main plan, both in the establishment phase of information technology and in the production of telematics services (e.g., distance learning, health and other public services) to be provided through this system, has been to raise the local contribution to its maximum. In addition, it is aimed to provide the proficiency of the country in information technology by creating demand for product and technology development activities on this concrete ground.

The main plan of the National Information Infrastructure has been prepared upon prime ministerial directive with the funding provided by the public sector. However, none of the governments has undertaken this plan and it has not been put into practice. As a result, in the area of informatics, Turkey could not prevail over the role of "user of information and telecommunication technologies", tailored to her in the Main Plan, the World Bank Report, 'Turkey: Informatics and Economic Modernization' (WB 1993), prepared with the collaboration of the Turkish Government in the early 1990s.

Area of Development II:

The adaptation of the country's industry to the flexible production and flexible automation technologies that became a substantial principle of international competition

Result: Turkey could not attain a significant accumulation of capabilities regarding the development and production of component, equipment, tools, system, production techniques, and machinery. A dominant portion of the companies is dependent on foreign firms or their foreign partners in this regard. Within the past decade, no systemic attempt on the national scale has been done to get competent in these technology areas important for all sectors.

Area of Development III:

The upgrading of the railway system with fast trains and development of rail systems in intra-city transport

Result: Regarding the fast train issue, it is a well-known fact that let alone development, Turkey did not even make any attempt, whereas a number of countries (France, German, Sweden, Italy, Spain, Japan, South Korea, etc.) established their own fast train systems, and thus became capable of this technology. In the search for integration with Europe, Turkey is far from integrating with the inter-cities / countries rail-based transport system with its existing situation.

Area of Development IV:

Pursuing a strategy based on the push of field and product selection in the space industry, aerial and defence industries.

Result: Turkey did not make any serious attempt in this field within the past decade, and could not achieve a significant development, even in an area like defence industry, which is particularly essential to be competent in technology.

Area of Development V:

Focus on R&D in genetic engineering and biotechnology; opportunities on GAP and the like projects

Result: The decisions taken in the SCST meeting, "Determining the National Policy on Molecular Biology, Genetic Engineering, and Biotechnology", could not be realised. No GAP based opportunity could be provided, either.

Area of Development VI:

Focus on environment friendly technologies, energy-saving technologies and environment friendly energy technologies; and instant development and expansion of their countrywide application areas

Result:

- BTSTP (Science, Technology and Industry Discussions Platform) Report of Energy Technologies Workgroup, May, 1998
- BTSTP (Science, Technology and Industry Discussions Platform) Report of Environment Friendly Technologies Workgroup on Industrial Sector, October, 1998

Both reports, like the previous ones, have been presented to a number of authorities, however, almost none of the suggestions proposed in these reports have been brought to life.

Area of Development VII:

Industrial investments as an extension of R&D on the advanced material technologies in a direction supporting the other areas of development

Result: BTSTP founded the Science and Technology Policies Workgroup on the Field of Advanced Materials in 1995, which published their report "Strategy and Policy Proposals for Turkey" in September 1995 and presented to the authorities concerned. Again, the suggestions in this report have not been realised.

<u>Decision 3:</u> The measures to be taken to attain the main targets of the Science Policy approved by the Council are stated below:

a) Measures on providing financial resources

i. Creation of competition and demand in the domestic markets by means of public purchases,

Result: This subject could be dealt with an integrated approach including also the civic purchases at last at the SCST meeting on August 27, 1997. Despite the efforts of some sectors and institutions, this target could not be achieved.

ii. Utilisation of offsets of the large-scale investments implemented with foreign partners, to provide an additional resource in the realisation of targets by means of TÜBİTAK as intermediator and/or coordinator

Result: In the SCST meeting on June 2, 1998, the decision quoted below has been undertaken with the heading "Taking the Maximum Advantage out of the Off-set Agreements to Raise the Technological capability of the Country": however, no mechanism could be established to provide offsets to be used in the addressed direction.

iii. The support of the public R&D projects by means of one institution, TÜBİTAK, as much as possible; in case this is not convenient, the coordination of those projects with TÜBİTAK regarding their appropriateness to the prioritised fields

Result: At the moment, in addition to TÜBİTAK and SPO, using the funds reserved from the budget, Ministry of Finance also supports the basic and practical researches in universities. The annual funds utilised by Ministry of Finance and SPO can exceed that reserved for TÜBİTAK. It is a waste of resources to divide such a limited one to three authorities, totally at their own disposals, without being associated with a national foresight considering the priorities of the country in the area of basic and practical sciences. It should carefully be evaluated the situation, which emerges as a result of the distribution of these resources to a number of projects by each of those institutions, with respect to support policy of basic and practical sciences.

iv. Transfer of additional resources from Development and Support Fund to TÜBİTAK, for the implementation of international mega projects that it participates besides its routine activities

Result: In 1993, 95 billion Turkish Liras (in terms of 1993 prices in effect) has been reserved for TÜBİTAK, from the Research and Development Fund. Then, In 1996 financial year, 30 billion Turkish Liras (in terms of 1996 prices in effect) has been reserved for TÜBİTAK for the implementation of two projects, one of which is the 'internet'. In the following years, it could not be possible for TÜBİTAK to benefit from the fund, except the limited contribution to National Academic Network and Information Centre.

v. The selection of the technologies and know-how by a Technology Evaluation Centre, in which TÜBİTAK will play an active role

Result: This decision has not been taken into consideration. In fact, the possibility of implementing such a decision in market economies is rather low.

b) Mitigations regarding human resources creation

i. The coordination under of the doctorate programs in abroad, implemented by different institutions, under the same 'umbrella'

Result: This issue has been tried to be resolved with a decree of YOK (The Institution of Higher Education) published in the Official Gazette on February 3, 1996; however, there are still major criticisms on its efficiency and functionality.

ii. Measures should be taken in order to prevent the avoidance from natural sciences at the undergraduate level in universities and to support that would encourage these fields

Result: TÜBİTAK tries to achieve this by the 'Science Olympiads', 'Research projects Competitions' targeting at the primary and high school students.

iii. The scientist transfer program from the former Soviet Union, which has been implemented successfully since 1992, should be continued with an extended scope

Result: Two programs have been put into action regarding this decision on the extending the scope of the transfer program of scientists from the former Soviet Union and the Eastern European countries: TÜBİTAK-DOPROG Scientist Invitation Programme, and TÜBİTAK-DOPROG Research Support Programme.

c) Measures on increasing the part of the private institutions in the R&D expenses:

i. The encouragement of the R&D activities in small and medium – sized industries

Result: This is an important opportunity for SMEs (Small and Medium-sized Enterprises), however, they cannot benefit to the anticipated extent.

ii. The encouragement of the multinational companies investing in Turkey to establish R&D units in our country

Result: An important point on providing this encouragement was the regulations regarding the intellectual property rights. In addition, it may be anticipated that the newly founded technology development regions may also have an encouraging effect on the foreign firms in establishing R&D departments.

iii. In order to provide the establishment of the risk capital market, the conclusion of the studies regarding the legal arrangements that encourage the development of the risk capital companies by the private sector

Result: The existing legislation requires to be improved in a manner that could encourage technology-based capital investments in particular, in order to settle the risk capital culture, to familiarise the risk capital investment partnerships, in addition to the risk capital investment partnerships, to encourage the establishment of ‘risk capital management companies’.

iv. The technopark facilities, which are important tools in developing the collaboration between the universities and the industry, to be implemented in coordination with TÜBİTAK

Result: It will be revealed by the practice had in the course of time whether the anticipated benefits are provided by the technoparks established.

v. Encouraging the transition from production based on license agreements to authentic design

Result: The R&D Support implementation together with the Law on Technology Development Regions may have accelerating effects on the transition from license agreements to authentic design.

vi. Updating of the Laws on Patent and Intellectual Property and inclusion of the software sector, the most essential part of the informatics sector, within the framework of Intellectual Property

Result: A significant improvement has been achieved in this issue after 1993 decisions.

d) Measures to increase the level of contribution to science and technology in the world

i. Centres of excellence should be established. For this purpose, the Council adopted in principle the establishment of Theoretical Research Centre in Istanbul and assigned to TÜBİTAK the preparation works. A similar centre has been accepted in principle to be established in the GAP region to conduct studies in the field of Biotechnology.

Result: Except for the Basic Sciences Research Institute (Feza Gürsey Research Institute) established jointly by TÜBİTAK and the Boshphorous University, there is no significant development on this issue.

ii. The establishment of the Turkish Academy of Sciences, which encompass both positive and social sciences

Result: Turkish Academy of Sciences (TÜBA) has been founded with the decree law number 497 on September 2, 1993.

iv. The encouragement of the scientific publication activities on the international level

Result: From 1993 to September 2002, an amount of 5 trillion TL incentives (in terms of 2002 prices in effect) has been provided for a total of 31.192 scientific publications. According to the ranking based on the country addresses of the natural sciences articles in the Science Citation Index, Turkey raised its score from 41st as she was in the end of 1980s, to 22nd in 2002 with 9303 articles, particularly accelerated after 1995.

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