ECONOMICS OF THE PATENT SYSTEM

A Ph. D. Dissertation

by

ALİ NİHAT DİLEK

Deparment of Economics

Bilkent Üniversitesi

Ankara

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The Institute of Economics and Social Sciences

of

Bilkent University

by

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ABSTRACT

ECONOMICS OF THE PATENT SYSTEM

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Since knowledge has "public good" characteristics, it is shown that the price system cannot determine the efficient allocation and production of knowledge. As a result, alternative allocative mechanisms are proposed as solutions to the public goods problem. But knowledge differs from classical public goods. Because of these differences, various arrangements have been proposed to deal with allocational problems in the production of knowledge. One of these arrangements refers to the patent system, where the society is granting private producers of new knowledge exclusive rights to the use of their creations, thereby forming conditions for the existence of markets in intellectual property and enabling the originators to collect fees for the use of their work by others. The thesis is about the economics of patent protection. After considering the economics of knowledge and discussing the history of the patent system and characteristics of the U.S. Patent Law, the thesis studies the international trade dimensions of intellectual property. Thereafter, partial and general equilibrium models of the patent system are developed for the study of the characteristics of the patent system and for the analysis of the Trade Related Aspects of Intellectual Property Rights (TRIPs) Agreement. It is shown that welfare cost of the patent system increases with increases in patent duration, degree of love of variety of the society, and the country size. The North – South patent protection model developed in the thesis, deals with possible effects of patent duration on technological differences between these poles. The findings imply that, technological lag between developed and developing countries is non-decreasing in global patent duration.

Key Words: Patent System, Intellectual Property Rights, Knowledge, Trade Related Aspects of Intellectual Property Rights.

ÖZET

PATENT SİSTEMİNİN EKONOMİSİ

Dilek, Ali Nihat

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Fiyat sisteminin, bilginin üretimini ve kaynak tahsisini verimli olarak belirleyemediği gösterilmiştir, çünkü bilgi kamu malı karakterine sahiptir. Sonuç olarak kamu malı problemine, alternatif kaynak dağılımı mekanizmaları önerilmiştir. Fakat bilgi klasik kamu mallarından farklıdır. Bu farklılıkları nedeniyle, bilgi üretimindeki kaynak tahsisi problemi ile ilgilenmek üzere çeşitli düzenlemeler önerilmektedir. Bu düzenlemelerden bir tanesi patent sistemini kapsamaktadır, toplum yeni bilgi üretenlere özel haklar vermekte ve bu yolla fikri haklar için bir piyasa yaratmakta, bilginin yaratıcısına, bilgisinin kullanılması karşılığında gelir elde etmesi olanağını sağlamaktadır. Bu tez patent korumasının ekonomisi hakkındadır. Bilginin ekonomisini, patent sisteminin tarihini ve Birleşik Devletler'in patent yasasını ele aldıktan sonra, fikri hakların uluslararası ticaret boyutunu incelemektedir. Daha sonra patent sisteminin karakteristiğini incelemek ve Ticaret ile Bağlantılı Fikri Haklar Anlaşması'nı analiz etmek için kısmi ve genel denge çerçevesinde patent modelleri geliştirilmiştir. Patent sisteminin refah üzerindeki maliyetinin; artan patent süresi, toplumun çeşitliliğe olan sevgisi ve ülke büyüklüğü ile birlikte arttığı gösterilmiştir. Tezde patent süresinin teknolojik farklar üzerisindeki olası etkisini incelemek üzere bir Kuzey – Güney modeli de geliştirmiştir. Sonuçlar, gelişmiş ve gelişmekte olan ülkeler arasındaki teknolojik açıklığın, patent süresinin artması ile arttığını göstermektedir.

Anahtar Kelimeler: Patent Sistemi, Fikri Mülkiyet Hakları, Bilgi, Ticaretle Bağlantılı Fikri Mülkiyet Hakları.

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CHAPTER 1

INTRODUCTION

According to the World Bank (1999), poor countries differ from rich ones not only because they have less capital but because they have less knowledge. Knowledge is critical for development and the degree of the success of the countries to acquire and use knowledge determines the time path of their well beings over time. But knowledge as a commodity has peculiar characteristics. It has no obvious natural units of measurement. Unlike ordinary tangible commodities, the use of a piece of knowledge by one agent does not exclude others from the simultaneous usage of the same knowledge. Furthermore, knowledge is indivisible and durable, and the production of it is subject to increasing returns to scale. Once a bit of knowledge has been obtained, the information can be used again and again without exhausting it. The cost of transmitting knowledge in codified form is negligible compared with the cost of creating it. The marginal cost of reproduction and distribution is rather low. But the original production of knowledge requires substantial costs. These characteristics, which are the main characteristics of public goods, indicate that market forces cannot determine the efficient allocation and production of knowledge. Knowledge is also important in the economic growth of countries. Growing economies produce more quantity, better quality and more variety of goods and services. Growth arises from the accumulation of primary factors of production, capital and labor, and total factor productivity growth. Solow (1956) argues that 87.5 percent of per capita growth rate cannot be associated with factor accumulation. More recent studies estimate a lower figure for total factor productivity growth, but growth economists nonetheless agree that, knowledge generation and, through it, the productivity gains are needed in order to achieve sustainable growth over the long run.

In the literature of public finance economics, alternative allocative mechanisms are proposed as solutions to the public goods problem. There are three principle alternatives. One is that society should give independent producers publicly financed subsidies and require that goods be made available to the public freely or at a nominal charge. A second mechanism would have the state levy general taxes to finance its direct participation in production and distribution of the good. Here, again, the objective is to supply the good without having to charge prices for it. The third solution is to create a publicly regulated monopoly authorized to charge consumers prices that will secure a normal rate of profit. These are the solutions proposed for classic public goods such as national defense, flood control systems, radar lending beams and lighthouses.

Although information qualifies as a public good, it differs from classical public goods in two respects. The first difference is that the contents of information will not be known to interested parties beforehand. The second difference is the cumulative and interactive nature of knowledge. The stock of scientific knowledge grows by increments, with each advance building on and sometimes altering the significance of previous findings in complicated and often unpredictable ways. As a result, it is generally difficult even for creators to determine borders of their intellectual property. In general, it is difficult to enforce the property rights protection even though it may be legally possible.

Because of the differences of knowledge from pure public goods, three alternative arrangements have been proposed to deal with allocational problems in the production of knowledge. The first arrangement stands for the system of awarding publicly financed prices, research grants based on the submission of competitive proposals, and other subsidies to private individuals and organizations engaged in intellectual discovery and invention, in exchange for full public disclosure of their creative achievements. The second arrangement is associated with government's contracting for intellectual work, the products of which it will control and devote to public purposes. The third arrangement refers to society's granting private producers of new knowledge exclusive rights to the use of their creations, thereby forming conditions for the existence of markets in intellectual property and enabling the originators to collect fees for the use of their work by others.

This thesis focuses on the economics of third arrangement proposed to deal with allocational problems in the production of knowledge, namely the patent system. Chapter 2 considers the economics of knowledge, general discussion of the the patent system including a discussion of its history and characteristics of the U.S. Patent Law, and survey of the literature on the economics of the patent system. Chapter 3 studies the international trade dimensions of intellectual property. Chapter 4 is on the economics of patent protection. The chapter considers, besides the partial and general equilibrium models developed, a North-South patent protection model developed for the analysis of the Trade Related Aspects of Intellectual Property Rights (TRIPs) Agreement. Chapter 5 constructs a North – South patent protection model, which deals with possible effects of patent duration on technological differences between these poles. The thesis concludes with Chapter 6 summarizing the main results of the study.

CHAPTER 2

KNOWLEDGE IN RESOURCE ALLOCATION

In a path breaking study Nobel laureate Robert M. Solow (1957) estimated that 87.5 percent of the increase in gross output per worker-hour from 1909 to 1949 in the United States could be attributed to technological change. A subsequent study by Denison (1985) led to a somewhat lower estimate, but Solow's general conclusion as to the relative importance of technological advance remained unchanged. The purpose of this chapter is to study the role of knowledge and hence of technological change[1] in the allocation of resources. Section 2.1 emphasizes the importance of knowledge in resource allocation. Section 2.2 provides the basics of patent system and alternative forms of economic organizations in inventive activities. Section 2.3 investigates the history of patent system and the U.S. patent system. Section 2.4 considers the welfare analysis of patent system, relationship between patent system and market structure, effects of patent system on information diffusion, and value of patents.

2.1 Resource Allocation, Economic Growth and Knowledge

2.1.1 Economics of Knowledge

Arrow - Debreu[2] model of competitive economy, which follows Walrasian[3] and Paretian approaches, is one of the most notable achievements in economic theory. The

---

[1] Technological change consists of not only knowledge, but also improved organizations and X-efficiency.

[2] Both of the authors won Nobel Prize for economics in different years.

[3] Walras equilibrium can be defined as the state where the value of the excess demand is zero. Alternatively, each individual satisfies his or her wealth constraint, so that the value of his or her excess demand is zero.

theory establishes requirements of the existence and optimality of competitive equilibrium. Although many articles contributed[4] to this development, the resulting structure is mainly based on a series of articles, including Arrow and Debreu (1954), Debreu (1959) and Arrow (1970).

According to Arrow (1970), the feasibility and efficiency of the competitive system depend largely on the assumptions of convexity, universality of markets and absence of uncertainty. Convexity implies the absence of indivisibilities and increasing returns to scale in production. The assumption of universality of markets implies the existence of markets for all commodities where transactions take place. In economies where the assumptions of convexity and universality of markets are satisfied, there are no public goods and no externalities. All goods are private goods. These three assumptions together with the assumptions on private ownership, largeness, and the assumption that each economic unit has perfect knowledge about prices, its preferences, its production and consumption sets assure the feasibility and efficiency of the competitive mechanism as shown by Debreu (1959).

Subsequent studies have extended the Arrow - Debreu theory to take account of asymmetries in information among different agents, incompleteness of markets, and sequential markets. Actually these extensions yield new developments in equilibrium theory. Namely, temporary equilibrium, overlapping generations equilibrium and rational expectations equilibrium. However, it is more useful to review the original Arrow - Debreu general equilibrium[5] theory at this point. Indeed, the major concern of Arrow - Debreu theory is to evaluate the applicability and efficiency of market system, two of the oldest and important questions of neoclassical theory. The proof of the theory is based on the two techniques of mathematics, namely convexity theory (also known as separating hyperplane theorem[6]) and fixed point theorem[7]. The Arrow

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[4] Actually many other economists and mathematicians contributed to the development of this outstanding theory of general equilibrium.

[5] The Arrow - Debreu model can be extended to several directions, for example it may bear uncertainty, public goods or external economy concepts with special interpretations.

[6] The separating hyperplane theorem simply says that there must be a separating hyperplane between any two disjoint convex sets.

[7] The fixed point theorem is established by Brouwer and generalized by Kakutani (1941).

- Debreu model can be analyzed within three important concepts, namely commodities, consumers, and producers.

A commodity is characterized by its physical properties. However, commodities are also distinguishable by their temporal and spatial properties. Debreu (1959) states that, "... a good at a certain date and the same good at a later date are different economic objects, and the specification of the date at which it will be available is essential ... wheat available in Minneapolis and wheat available in Chicago play also entirely different economic roles for a flour mill which is to use them. Again, a good at a certain location and the same good at another location are different economic objects, and the specification of the location at which it will be available is essential". In this context all goods and services can be defined as Arrow- Debreu commodities[8] with respect to their specifications. On the other hand, it is nearly impossible to find a market for a pure Arrow - Debreu commodity in reality. Thus, second best transactions take place. This special treatment of commodity enables the model to be applied in several different frameworks. Shortly, a commodity is a good or service completely specified physically, spatially, and temporally. Each commodity is also associated with its price. Price system relatively defines the value of each commodity. The Arrow - Debreu model concerns the allocation of commodities between agents. Market is established only once at one point in time, and all allocations are achieved through exchange. Actually markets can be settled many times, whereas no transaction takes place except in the first opening, since all agents have the full information regarding all contingencies and the market thus repetition of market settlement is unnecessary[9].

A consumer can be characterized by her preferences and by the limitations on her choice. The role of the consumer is to determine a complete consumption plan out of her possible consumption plans. Consumers' choice must satisfy their wealth constraint given prices. Consumers' consumption set consists of all possible consumption plans, and it is assumed that it is a convex set. Each consumer has well

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[8] All Arrow - Debreu commodities define the commodity space of the model and every action of agents is a point in this space.

[9] There is no incentive to revise production or consumption plans, reopen the market, or trade shares.

defined preferences, which are complete, transitive and which have continuous ordering. Consumers' preferences can be represented by utility functions. Consumers' problem is a utility maximization problem. Utility is defined on the entire consumption plan, not the instantaneous consumption. The Arrow - Debreu model assumes that preferences are convex and non-satiatied. The convexity assumption indicates that commodities are infinitely divisible. If there are many agents in the economy or the agents are small with respect to the economy, the non-convexity of preferences has no bite. The non-satiation hypothesis implies that there exists always a more preferred consumption plan for each consumer. Alternatively, non-satiation means that every agent spends all his income in equilibrium.

A representative producer is characterized by its owners' shares and by its technology. Producers transform commodities using their technological capacities. A production set is said to include all production possibilities given its limited technological knowledge. Producer's problem is defined as profit maximization within its production set given prices. This production set is assumed to be convex, closed, and contain the no production[10] case. That is to say, the model also assumes that there is a possibility of free disposability. The convexity hypothesis implies that production plan is infinitely divisible, and increasing returns to scale is out of scope. As mentioned in consumers' case, the small size of each producer relative to the whole economy makes indivisibility unimportant. Sum of all producers' output is called total supply of economy. The model also rules out free production possibility and reversability of production process. The model implicitly assumes that all possible future technologies are identified. That is to say, producers are aware of not only existing but also the frontiers of future technology. However, this does not mean that producers have the necessary know-how of future technologies. They are only aware of the possibilities and the outcome of future technologies. Moreover both consumers and producers are price takers.

In this context, equilibrium in Arrow - Debreu model can be defined as follows: Firstly, the model introduces total resources, which determine attainable actions of each agent. That is to say, all of the producers' and consumers' actions must be

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[10] Any producer has the possibility of producing nothing.

compatible with the total resources of the economy. The economy is assumed to be a private ownership economy, which means that consumers own the resources. Private ownership economy indicates that producers are controlled by their shareholder consumers. In the model, market equilibrium is a state when excess demand is zero. An attainable state of the economy is called equilibrium, given prices, when no producer can increase its profit and no consumer can increase her utility without increasing expenditure. Alternatively, the model implies that there always exists a proper price system, which clears all markets. Actually an equilibrium is defined by a set of prices, a set of production plans, and a set of consumption plans, which satisfies profit and utility maximization problems of agents and equality of total supply and demand.

Before stating the first and second welfare theorems, it is worthy to make the Pareto optimality concept clear. An attainable allocation is said to be Pareto optimal[11] (or Pareto efficient) if there is no other feasible allocation that all agents prefer. Every competitive equilibrium is Pareto optimum (first welfare theorem) and essentially every Pareto optimum allocation is a competitive equilibrium (second welfare theorem) under convexity assumption and rearranging the initial endowments of commodities and ownership shares. Clearly, the first welfare theorem expresses the efficiency of the ideal market system without dealing with the income distribution issue. On the other hand, the second welfare theorem implies that income redistribution should be achieved by a lump sum transfer without disturbing prevailing market prices.

As mentioned by Arrow (1962), perfectly competitive economy has a great role in the efficient allocation of resources. In this equilibrium, each consumer maximizes her utility given initial resources including firm shares and price set. Each producer also maximizes its profit given the same price set. Aggregate production plus initial resources are equal to aggregate consumption. In this system, prices are the same for all individuals. Agents' consumption and production decisions are independent. Arrow

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[11] Debreu (1959) defines optimality as follows; "... defined as an attainable state such that, within the limitations imposed by the consumption sets, the production sets, and the total resources of the economy, one cannot satisfy better the preferences of any consumer without satisfying less well those of another".

also indicates that, there is no other resource allocation, which improves agents' utilities or profits. On the other side, competitive equilibrium also indicates that any non-competitive solution can be improved by further exchange.

As previously mentioned, the model has some critical assumptions, namely universality of market, convexity and absence of uncertainty. Actually, universality of market assumption of the model cannot be easily satisfied in real world where time is relevant. Moreover, the presence of increasing returns to scale also disturbs the results of the model unless this deficiency is relatively small with respect to market. These real world problems indicate an imperfect competitive equilibrium. They are handled by monopolistic competition or game theory approaches. Existence of uncertainty also affects results of the model. Arrow suggests that any uncertainty can be put into the model by making detailed contracts. Insurance and common stock are two real world applications in the case of uncertainty, but these are not perfect solutions. All these problems about the validity of assumptions can be theoretically solved to some degree. Externalities, uncertainties can be regarded as Arrow - Debreu commodities. In this sense, they can be internalized, and then indications of the theory remain valid. According to Arrow, externality or more generally market failure are the results of high transaction costs. For example, if the cost of creating a market for public goods is high, its existence is no longer worthwhile. Arrow also indicates that, there are three types of transaction costs, namely exclusion cost, cost of communication and information, and cost of disequilibrium.

It should be noted that the Arrow - Debreu model of general equilibrium abstracts from the consideration of knowledge and its generation. It assumes that knowledge is freely available to all economic units. But, today knowledge is becoming a critical asset for firms and individuals. The new society is called the knowledge based economy. In this society, knowledge is no longer freely available.

How do we incorporate knowledge[12] into the model of general equilibrium? At this point, difficulties arise when we consider knowledge as a commodity. Marketability

[12] Today knowledge is of two types: "codified" and "tacid". Knowledge is codifiable if it can be written down and transferred easily to others. Tacid knowledge is often slow to acquire and much more

of knowledge is limited by the following facts: (1) one person's use of a particular bit of knowledge does not preclude the use of the same knowledge by others - nonrivalrous, (2) when a piece of knowledge is in the public domain, it is difficult for its creator to prevent others from using this knowledge - nonexcludable.

These two properties, which are also the main characteristics of public goods, make it possible for people to use knowledge without paying for it. Since the assumption of universality of markets is no longer satisfied, the resource allocation is not efficient. Knowledge is also a key input in the production function. However, nonrivalrous characteristic of knowledge implies the presence of increasing returns to scale[13]. This special property of knowledge also violates perfect competition. Moreover knowledge is employed as an input in the production of new knowledge. This positive-feedback-type characteristic also violates the assumption of the absence of increasing returns to scale in production. Knowledge is also indivisible, thus it fails to satisfy the divisibility requirement of Arrow - Debreu model.

The information generation process has a strong effect on economic welfare. Empirical studies indicate that output per labor continuously increases, and these increments cannot be explained by increased capital. Most of the academicians state that information generation is the major source of this productivity gain. Therefore, optimality of resource allocation for invention is highly critical. Perfect competition yields optimal resource allocation under certain hypothesis. However, competitive market structure for information generation fails to be optimal, since information generation processes do not satisfy divisibility, appropriability, and certainty. Indivisibility, the first reason of failure indicates that marginal cost pricing of information results in zero or perhaps negative return for the producer, thus ceases its production. Appropriability means that, private and social benefits of information are strictly different. The inventor cannot get whole social surplus of his invention, hence cannot allocate resources optimally. Finally, inventive activities are highly uncertain.

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difficult to transfer. Examples include the knowledge built up during an apprenticeship, or familiarity with using a particular technology. Because of its non-transferability, tacid knowledge is often a source of comparative advantage.

[13] Arrow indicates that "There has been a long tradition, going back to Adam Smith (1776), that technological progress is somehow intrinsically associated with increasing returns".

Not only success of the research project, but also its economic return is uncertain. In pharmaceuticals industry, for example, only one new drug out of four, that enter clinical testing, are ever marketed. Furthermore, it turns out that only 30% of drugs that are marketed covers their total cost. This means that only 7.5% of all research projects in pharmaceuticals industry covers their cost.

At this point, a question which arises is whether knowledge has always been a critical asset for firms and individuals. According to Rosenberg and Birdzell (1986), the answer is probably 'no'. They studied the link between pure science and economic growth of Western society. Their findings suggest that, science and industrial technology[14] have always tracked separate paths in the West before the 19th century. Scientists had no commercial worries, their main aim was to explain natural phenomenon. On the contrary, industry had no interest in these scientific explanations, since they were not, for the most part, satisfying economic needs. They usually had no direct economic application, they emanated mainly from academic and independent scientists whose incentives were not basically economic. On the industry side, technological developments were achieved by artisans and engineers with little or no scientific training. These technological developments were primarily based on previous experiences, and craft traditions, which were nothing but learning by doing type knowledge generation. Industrialists in general did not employ scientists. These observations clearly reveal that, there were no deliberate investments in research and development activities in industry.

The situation changed in the last part of the 19th century. The derivation of new or improved materials, products and processes from basic scientific studies mainly in chemistry, electricity and other areas became the concern of industrial scientist. In fact these new materials, products and processes have potential commercial value. The narrowing gap between scientific studies and industry during the 19th century can be explained as follows. Firstly, Western basic science created explanations for natural phenomenon that possessed valuable potential applications in industry. Secondly, West provided several necessary autonomous institutions, which enabled the transfer of basic scientific knowledge accumulation into the industry, eventually

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14 Industrial technology can be defined as applied science in industry with commercial aim.

into economic growth. In this sense, the major contribution of the West was the development of an economic system for innovation[15]. Actually Chinese, Indian and Islamic cultures had developed several scientific inventions, whereas they lacked systematic translation from basic science to industrial application.

The first phase of Western economic system for innovation, alternatively transition from basic science to industrial application were the rise of industrial research laboratories which performed testing, measuring, analyzing, and quantifying tasks. These laboratories hired many scientists systematically for the first time in industrial history. However, these laboratories contributed to the standardization of production processes rather than invention or new scientific insights. Rarely, these scientists produced new products of great commercial value, but they improved the materials that were used in known product. Actually only a very few new technologies had such economic significance. At the end of the 19th century, industry was moving a closer synchronism with basic science. During previous centuries, ideas of basic science were waiting for hundreds of years to find a commercial application. On the contrary, last part of the 19th century witnessed the fact that the intervals were growing shorter between scientific discovery and its commercial application. By the early years of the twentieth century, industrial research had clearly turned toward the development of new products and processes. If the knowledge required for innovation lay on the frontiers of science, then scientists of industrial laboratories studied on or even beyond the frontiers.

According to Rosenberg and Birdzell, there is no doubt that basic science contributed to the success of Western industrial science. However, the rise of Western industrial science cannot be completely explained by either contribution of extensive basic science or scale of the West. Actually, the comparative success of the West is based on three important points: the decentralization of the selection of innovation projects, the incentives for innovation, and the diversity of research agencies.

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[15] Green Paper on Innovation (1995) defines innovation as follow, "It denotes both a process and its result...it involves the transformation of an idea into a marketable product or service, a new or improved manufacturing or distribution process, or a new method of social service".

Firstly, innovation projects, which aim to generate new products, services, or processes, bear high uncertainty. It is difficult to predict the success or failure of projects in the beginning. Until a product or process has actually been developed, there is uncertainty about its technological feasibility, and its cost. There is also uncertainty about its commercial success which is determined by consumer's response. The West deals with this problem by decentralizing the selection of innovation projects. Clearly Western economies allow a large number of independent enterprises, as well as individuals who might form new enterprises, to decide to perform or ignore proposals for innovation. In this sense, the West provides a dynamic economic environment for innovation projects, which generally require organizational changes. Rosenberg and Birdzell conclude that, innovation is more likely to occur in a society that is open to the transformation of new enterprises than in a society that relies on its existing organizations for innovation. Therefore, West solves the uncertainty problem to some degree by a decentralized statistical selection mechanism.

Secondly, the openness to new forms of enterprises, or to a change in the organization of existing ones, has put Western enterprises into a highly competitive environment. Since new technologies developed by rivals may severely injure them. In this way, the openness of Western societies to the new enterprises, or to changes in the operations of existing organizations encourages innovative activities by the threat of penalty for failure to innovate.

Thirdly, Western industry supports a wide array of different scientific and industrial organizations. These research organizations can be diversified with respect to their size, financial structure, goals, personnel, and facilities. It is important to note that, the West has no noteworthy obstacles to this proliferation of research organizations. These various research institutions both cooperate and compete with each other, and create a dynamic industry. In this context, there was no attempt to standardize these various structures; conversely diversity and flexibility was allowed. That is precisely what was needed to shape institutions according to their own special needs, since different sectors may have special requirements.

Economic growth results from innovation, namely the introduction of products, processes and services. Science and technology are key to innovation, but they are not sole inputs. The extensive growth in scientific and technical knowledge could not have been automatically transformed into continuing economic growth of the West. Western societies' social consensus on the demand of new products, services and innovation caused this transformation. Actually, markets of the West, most basic economic institutions, helped this transition, since they conferred great rewards on successful innovations and penalized failures. Rosenberg and Birdzell indicate that high degree of autonomy among the political, religious, scientific, and economic environment of West enables the enormous development of technology.

Shortly, with the growth of knowledge based economy, the West developed a system for innovation and invention. Industrial research laboratories applied scientific methods and knowledge to commercial problems.

2.1.2 Role of Patent System in Information Generation

Information generation process is self-sustaining, each newly created information which enters public knowledge domain, also helps further information generation activities. However, the role of patent system in the generation and diffusion of information has been under debate for prolonged periods of time. Patent system is designed to achieve a balance between private incentive to invest in research and development and the need to protect public interest. Patent system is supposed to foster innovative activities by giving exclusive ownership rights to the inventor. Unfortunately the success of this theoretical approach is still controversial.

Importance of patent protection varies across sectors; for example, pharmaceuticals and information technology industries are very sensitive to patent protection. As Viscusi, Vernon and Harrington (1995) state, American pharmaceuticals industry heavily depends on effective patent protection, since copying information in this industry is technically easy. Actually pharmaceuticals is a leading high-tech industry in the United States. Its research and development spending per sales is permanently at the top of all American industries. In this environment, research intensive pharmaceutical firms strongly advocate the 1984 Drug Price Competition and Patent Restoration Act’s second part, which extends patent duration. Viscusi, Vernon and

Harrington also note that some brand name drugs, for example Zantac (Glaxo owns the patents on it), reach billions of dollars in sales. According to them, patent protection, brand loyalty and research and development scale advantage are the only sources of entry barriers to rival firms. In the case of infringement, scale advantage is not considered as important due to ease of copying. Moreover, huge amount of sales revenue could not be explained by the loyalty issue. Therefore, it can be concluded that, patent protection is critical in pharmaceuticals industry and absence of it may severely destroy innovative activities in this industry.

On the other hand, the number of patents granted in an industry does not directly reflect the intensity or quality of research and development in that industry. Nor does the patent indicate any concrete economic activity, since most patents have never been used in any productive activity. Patent values are highly skewed, that is to say, most patents do not bear any economic value, but some of them have enormous economic success in the market. Patent grants are also valued on the market and can be traded. This fact suggests that value of patents, as indicators of information, could be estimated to some degree.

According to Arrow (1962), uncertainty problem of information generation theoretically can be solved to some degree. He proposes that, options market for research projects may contribute to the solution, since markets for commodity options serve the function of achieving an optimal allocation of risk bearing among all the agents of economy. Actually, current economic system has devices for risk diversification, but they are limited, imperfect, and costly. Economists are aware that these devices can be improved theoretically. However, moral factors create a limit in practice. Total risk shifting may cause misuse of the system, for example, most of the research projects are performed and financed by public institutions in centrally planned economies, but these projects generally do not achieve economic success. The point is that, full insurance of inventive activities weaken the incentives to success. Therefore risk-shifting mechanism could not achieve optimum resource allocation for invention. Large commercial firms and many research projects also function as risk minimizing, but these are not perfect solutions. Then these large firms behave monopolistically, and create inefficient markets.

In fact, the problem at hand can be summarized as a tradeoff between optimum utilization of information and optimum production of information. Patent system is a complex system, which aims to balance these two opposite faces of information. Theoretically, patent system solves the inappropriation problem to some degree, since actual patent laws sharply determine the appropriation range of an invention, namely 20 years protection period, actions against infringements, etc. However, practical success of the system is still controversial. In this environment, it is expected that free enterprise economy is going to underinvest in inventive activities and research projects. Especially, basic research activities cannot be optimally allocated. The main reasons of underinvestment are high commercial risk, limited appropriation, and increasing return in utilization of information.

Arrow (1962) builds an optimal resource allocation model and compares the competitive, and monopoly solutions, and determines the level of incentives for innovation. In this model, private incentive to innovate is solved under both competitive and monopolistic market structures. The appropriation problem is assumed to be negligible. In the competitive case, one firm invents and charges an arbitrary royalty fee for invention. In the monopolistic situation, only the monopoly firm can invent, in this sense, entry into the market is restricted. The invention is assumed to be cost reducing. The model can be summarized as follows; both demand and marginal revenue curves are assumed to be downward sloping. Moreover, the model assumes that costs are constant before and after invention. The model deals with two different sizes of cost-saving inventions. In the first case, cost reduction is drastic, that is to say after invention, monopoly price is less than competitive price. In the second case, only a minor invention takes place.

In the major invention case, competitive firms' incentives are definitely greater than monopolist's incentive. In the second case, namely minor invention, the analysis reveals that the result is the same as in the first case. Therefore, this basic model implies that competitive firms' incentives are larger than monopolist's in both cases. The only counter-argument is based on greater appropriability in monopoly than in competition. Thus, in principle competitive case may induce more incentive to innovate and foster growth without effective patent protection.

It is also beneficial to compare these private returns with social return. In the major invention case, consumers are better off since price falls, the inventor may not receive total return of his invention. On the other hand, in the minor invention case, consumers are indifferent, since price remains the same, all return of invention is appropriated by the inventor. Therefore, major inventions are superior in public point of view. In any case, potential social benefit is always larger[16] than realized benefit. This result suggests that optimal resource allocation to invention cannot be achieved by market forces.

2.1.3 Economic Impacts of Patent System

Firstly, patent system has income distribution effect. Patent owners can make a positive profit from their contributions; theoretically stronger patent protection increases profit level. Therefore, stringency of protection affects income distribution between individuals. Moreover this concept can be extended to the international scale. As generally accepted, if northern multinational firms realize most of the innovative activities, then they may obtain positive profit. Nevertheless, this is nothing but a rent transfer from the south to the north. Clearly, stringency of patent protection may affect income distribution between countries.

Besides income distribution effect, patent system has productivity effect; since new products and processes increase productivity of firms. Stronger patent protection rewards inventive activities, thus fosters growth.

The third patent protection effect is expressed as spillover effect. Human creativity is a deep concept and has different dimensions. Generally, creativity starts with observation and perception. Specifically, most of the inventors investigate the state of the art technology first, then deal with further inventive steps. Patent system is designed to reveal the information behind these creative activities. Therefore stronger patent protection increases beneficial spillover effect.

Fourth effect of patent protection is on the ethical dimension. Original authorship concept dates back to ancient ages. Protection of original authorship incite further

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[16] This finding implies that there is a high risk of under-investment in inventive activities.

inventions. Clearly, profit is not the only motivation behind creative activities. Personal satisfaction and curiosity also fuel human creativity. Therefore ethical importance of protection of intellectual property should also be considered.

2.1.4 Knowledge and Growth Theories

So far, we have concentrated on the role of knowledge in resource allocation. Knowledge also has a role in economic growth. Economic growth has been studied mainly within the growth theory. Former studies are motivated by two important issues, namely the growth over time in living standards, and cross country differences[17] in growth rates. In the 1960's, the growth theory consisted mainly of the neoclassical model, as developed by Solow (1956). The Solow growth model is the starting point for almost all economic growth studies. The model focuses on four variables: output, capital, labor and knowledge[18]. It identifies differences in capital per worker as a possible source of variation[19] in output per worker.

In this framework, a brief investigation of Solow growth theory, which is also known as growth accounting, are beneficial. Firstly, the Solow growth model assumes that output changes over time only when its inputs change, which indicates that production function remains unchanged through time. On the other hand, if knowledge stock increases, then the amount of output produced from given quantities of labor and capital rises. This may be considered as a technological development[20] of production function. Solow assumes that there is a constant returns to scale production function, and labor and knowledge grow at constant rates. That is to say, knowledge[21] and labor are determined exogeneously. The Solow model indicates a balanced growth at the

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[17] Average annual growth rates are 6 percent for South Korea and 5 percent for Japan between 1960 and 1990. On the other hand, the rates are –1.7 for Chad and –1.3 for Madagascar during the same period. These indicate that rates of economic growth vary substantially across countries.

[18] Knowledge can also be interpreted as effectiveness of labor.

[19] There is enormous variation in per capita income across economies. The poorest countries have per capita incomes that are less than 5 percent of per capita incomes of the richest countries.

[20] According to Solow model, technological change multiplies the production function by an increasing scale factor.

[21] The model assumes that technology is exogenous. That is, the technology available to firms is unaffected by the actions of the firms, including R&D sector.

natural rate for the economy regardless of its initial point. The growth of output is always intermediate between growth of labor and growth of capital. The growth path provides that all markets are instantaneously cleared; thus, there is neither unemployment nor excess production capacity in the model. The model makes clear two potential sources of variation for cross country differences in growth and changes over time. Namely, differences in capital per worker and differences in knowledge level cause differences in output per worker. The model also shows that differences in capital per worker has only modest effect on growth.

As a result, many take physical capital accumulation to be the principle engine of economic growth. However, researchers in the neoclassical tradition are also documenting the importance of technological progress in economic growth. Studying the growth of the U.S. net national product per capita over the period 1869-1953, Abramowitz[22] (1956) notes that, the main source of the increase in net product per capita is not the increase in capital per capita but rather the productivity increase. Abramowitz makes a comparison between the decade 1869-78 and the decade 1944-53 and concludes that, net national product per capita increased approximately fourfold. Actually, population tripled during these periods, whereas net national product in constant prices increases thirteen times. Abramowitz indicates that, the input of resources per capita appeared to have increased relatively little while productivity of resources increased a great deal. He estimates that, the productivity of resources increased 250 per cent from 1869 to 1953. On the other hand, Abramowitz denotes that, composition of labor force changed, so its productivity also increased. The same kind of change also occured on the side of capital. These types of improvements in inputs are difficult to measure. In any case, Abramowitz determines that knowledge stock concerning the organization and production technique is increasing at a high rate. He is also aware of intentional economic activities in productivity, he states that "Our capital stock of knowledge ... has grown at a phenomenal pace. A portion of this increase – presumably an increasing proportion –

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22 Abramowitz (1956) also deals with three important economic growth concepts, firstly determination of net increase of aggregate output per capita, and its distribution among labor, capital input and productivity changes, secondly investigation of retardation or acceleration evidences in the growth of per capita income, thirdly determination of long term and short term fluctuations in the rate of growth of output.

is due to an investment of resources in research, education, and the like." He proposes that there is an increasing trend in investment in knowledge and gradual growth of applied knowledge resulting from this investment. According to him, this investment trend is sustained the growth since every other major element of resources is made for retardation in the growth of net product per capita.

Kendrick (1956) supports the findings of Abramowitz using U.S. data. Kendrick, considering the U.S. economic performance from 1899 to 1953, concludes that total factor productivity (TFP) explains 53 percent of the growth in real aggregate output over the period. He also determines that there is no evidence for retardation in growth. Finally, Solow (1957) shows that, technical change accounted for 87.5 percent of the growth in the U.S. gross output per man-hour over 1909-49. The remaining 12.5 percent was only associated with increased capital per man-hour. He also indicates that, technical change seems to be accelerating after 1929. Solow finally mentions that the model is based on the assumption that measured capital earnings fully reflect its contribution. In a more recent study, Denison (1985) states that, growth of national income can be broadly divided between changes in factor input, namely labor, capital and land etc., and changes in output per unit of input. The second type of source can be interpreted as technological progress. Denison reports that increase in factor input was contributing 63 percent of whole growth rate using the U.S. data from 1929 to 1982. On the other hand, remaining 37 percent of output growth is associated with the changes in output per unit of input. Denison precisely determines the contribution of advances in knowledge[23] as 28 percent of whole economy in actual national income. Denison also indicates that there has been a slow down in U.S. growth figure since 1970's. Therefore, one can conclude that, all growth accounting studies, to some degree, indicate the importance of knowledge for economic growth.

In summary, knowledge has many types, which are all accumulated and exchanged within the economy. Thus, it is virtually impossible to determine the value of knowledge. Actually, there is an ongoing controversy on how to measure the value of knowledge. In this context, growth accounting studies indirectly measure the contribution of it, by postulating that knowledge explains the part of growth that

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23 Advances in technological, managerial, and organizational knowledge belong to this group.

cannot be explained by the accumulation of tangible factors, such as labor or capital. This unexplained TFP growth is also known as Solow residual. However, all of TFP should not be associated with knowledge, since there may be other factors in the Solow residual.

The neoclassical growth assumed that increased factor productivity is exogeneous, i.e. it is due to increases in knowledge unrelated to economic decisions. But the new theories of economic growth, known as endogenous, stress that development of knowledge and technological change - rather than the mere accumulation of capital - are the driving forces behind lasting growth. According to new growth theorists, neoclassical growth models do not explain the central concepts of economic growth. In fact, these models conclude that capital accumulation cannot account for a large part of either long term growth or cross country income differences at least with the given definition of capital. However, growth in the effectiveness of labor can sustain permanent growth in per capita output. Romer (1996) indicates that differences[24] in output per worker cannot be explained completely by the differences in capital per worker, under the assumption that capital gains all of its private return.

In this context, new growth theorists propose two complementary views. The first view considers the accumulation of knowledge as a main source of economic growth. This type of endogeneous growth theory is pioneered[25] and developed by P. Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992). Actually this view of endogeneous growth theory is in line with Solow growth theory. On the other hand, the second view is contradicting with the findings of Solow growth theory. According to this view, capital accumulation is central to growth, whereas capital should be broadly defined in this case. These models include human capital concepts, and argue that physical capital's income share is a misleading indicator to determine the importance of capital in growth. Human-capital type growth theory is developed

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24 These differences denote either economic growth differences over time or cross country income differences.

25 According to Aghion and Howitt (1998), Kuznets, Abramowitz, Griliches, Schmookler, Scherer, Rosenberg, and Schumpeter had also pointed out the importance of endogenous technological progress for growth. Moreover, they state that, Brewer (1991) has traced the roots of endogenous growth idea back to John Rae (1834). However, analytical endogenous growth theory models were not constructed until early 1990.

by Lucas (1988), Azariadis and Drazen (1990), Becker, Murphy and Tamura (1990), Mankiw, D. Romer and Weil (1992), Kremer and Thomson (1994), Barro and Sala-i-Martin (1995).

In one of the pioneering studies, Romer builds a model which consists of intentional R&D investments arising from profit maximizing agents' desicions. The model consists of four basic inputs, capital, labor, human capital and a technology index. Human capital is differentiated from standard labor input. It is assumed that technology index can grow without a bound. In the model, a stock of skilled workers - researchers scientists, inventors, intellectuals - is available to generate ideas and new knowledge. The model has three sectors, namely research, intermediate goods[26], and final goods sectors. The research sector uses human capital and existing knowledge in order to produce new knowledge. This new knowledge is embodied in new designs. The researcher, upon obtaining a useful idea, sell it to a machine maker. These new designs or ideas are commercialized within the intermediate goods sector. The machine maker builds a machine around the idea, and rents the machine to a monopolistically competitive manufacturing industry who - by combining the machine with skilled manegerial input - retail the final product to consumers. This final good sector uses labor, capital, and output of intermediate good sector in the form of producer durables. Romer simplifies the model by assuming constant supply of labor, and human capital. Outputs of research sector, namely new designs and ideas are assumed to be protected by infinitely[27] lived patents. Romer also briefly identifies alternative institutions for research sector protection. These institutions are assumed to provide the right incentives for the creation and dissemination of knowledge by the private sector.

The greater the number of researchers and idea producers, the faster the economy grows. In this sense, Romer differentiates the largeness of population from its researcher intensity. According to Romer, stock of human capital, which has innovative capability, determines the rate of growth of an economy. Moreover, if

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[26] This sector exhibits increasing returns to scale in production due to nonrivalrousness of knowledge embodied in technology.

[27] Obsolescence possibility (or risk) is ignored in the model.

stock of human capital is too low, growth may not take place at all. Actually this last prediction is also in accordance with real world observations. Romer also identifies two attributes of knowledge, namely nonrivalry and nonexcludability. These are well known attributes of public goods. Output of research sector depends on the devoted amount of human capital and existing knowledge stock. That is to say, knowledge generating research sector is a self sustaining one, since the larger the stock of knowledge, the higher the productivity in this sector. This side of the model indicates a policy implication, open trade regimes allow countries' access to each other's knowledge stocks[28]. Therefore, integration increases the productivity of research activities and causally fosters worldwide growth.

Romer also points to the importance of interest rate in his model, since the model assumes that the benefits of research activities come largely in the future but its costs are paid immediately. If the interest rate decreases, then the rate of technological change increases. Therefore the rate of growth of economy is sensitive to the rate of interest. The model also implies that, in the absence of an efficient institution, which equates social and private returns of research, subsidizing the accumulation of human capital can be considered as a second best policy.

Despite the existence of strong theoretical background of endogenous growth theory, there are counter-arguments in the field of econometry. Clearly, Jones (1995) states that the scale effect prediction of recent R&D based endogenous growth model is not consistent with the time series evidence from industrialized economies.[29] According to Jones, the major endogenous growth models including Romer, Grossman - Helpman, Aghion - Howitt, all share scale effect prediction. That is to say, if the level of resources devoted to R&D are increased by a factor, then the per capita growth rate of output also increases by the same factor. Generally, the number of scientists and engineers hired by the research sector is used as an indicator for its resource usage. Jones indicates that, such a prediction receives little support empirically. On the other hand, Jones points that other aspects of endogenous growth theory remain valid. Therefore, Jones eliminates the scale effect prediction from standard endogenous

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28 It is implicitly assumed that their knowledge stocks have different contents.

29 Jones used the data of U.S., France, Germany and Japan.

growth model, and constructs an R&D based model of semi-endogenous growth. Finally Jones' semi-endogenous growth model proposes that subsidies to accumulation of human capital has no long run growth effects as suggested in Solow's growth model.

Empirical findings of Jones can be summarized as follows: human capital measured as number of scientists and engineers engaged in research sector increased from 160,000 in 1950 to 1 million in 1988 in the U.S. This figure indicates an increase of more than a factor of six. The evidence from other industrialized countries, namely France, Germany and Japan, is similar. On the other hand, the figure of average TFP growth rate remains nearly constant or even declines. In the light of empirical results, Jones concludes that "The assumption embedded in the R&D equation that the growth rate of the economy is proportional to the level of resources devoted to R&D is obviously false". Jones proposes some explanations for this inconsistency. Firstly, he suggests that the possibility of the addition of labor into the R&D sector requires the use of less skilled scientists[30]. Secondly, discovery of useful knowledge is getting harder. Thirdly, once the economy has accumulated a large stock of knowledge, each new idea has only smaller contribution with respect to prior ones in percentage terms. In addition, overlapping research projects can also be considered as alternatives.

Keely and Quah (1998) also deal with knowledge and its effects on growth. In their study, they review the role of R&D in a well established endogenous growth theory framework, and describe existing empirical research which considers R&D as a driving force behind economic growth. According to them, less developed and developing countries can transfer or copy the existing technology which are previously developed in industrialized countries. On the other hand, industrialized countries which stand at the edge of high technology, must improve their technology level by costly and difficult efforts. Intentional research activity is the most visible and systematic mechanism which pushes the frontier of technology.

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30 Eaton, Gutierrez and Kortum (1998) also denote this possibility by stating "...increasing research effort may force a country to use less talented researchers, we assume that the productivity of additional researchers declines as the fraction of researchers employed relative to the total labour force rises".

Keely and Quah identify the three main outcomes of endogenous growth theory and empirically evaluate them. Firstly, the relation between increasing amount of resource devoted to R&D and measured improvement in technology are studied. Keely and Quah conclude that, the number of patents do not reflect an increasing trend in resource devotion in aggregate growth. According to them, patents may not be sufficient to measure R&D output. On the other hand, they survey empirical literature and state that the relation is held in the individual firm level. That is to say, there is a positive relationship between technological growth and quantity of resources devoted to R&D sector. Further research is required to determine the validity (or invalidity) of this scale effect in aggregate case. Secondly, they evaluate the significance of patent protection in research sector. According to them, patent protection is effective in a few industries, only. Trade secrecy, lead time, and learning by doing are more effective than patent system in the rest of the industries. They indicate that, growth and IPRs related studies[31] should also consider the other forms of protection. According to them, in such a broad view, there is no conventional trade-off between R&D incentives and detrimental monopoly power created by IPRs protection. Keely and Quah also emphasize the importance of government and non-profit organizations in research sector. Government or non-profit organizations' research activities can be totally different from private ones. However, most of the studies model inventive activities only in profit seeking agents' body. They state that, these types of R&D activites are generally ignored in endogenous growth literature. However, their share[32] cannot be negligible. All these imply that, economies of knowledge must be properly established in order to achieve full potential of economic growth. Thirdly, dissemination and spillover potential of knowledge are investigated by Keely and Quah. They conclude that, knowledge spillovers take place, though as limited. Their study indicates that, these spillovers are concentrated in spatial, industrial, and political clusters. Actually this finding contradicts with the general assumption about the free dissemination of knowledge. Keely and Quah's other conclusions are as follows: their study identifies that technological progress is an important engine of

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[31] Gould and Gruben (1996) examined the role of intellectual property rights in economic growth and found a positive relationship.

[32] The share of government and non-profit organizations in total R&D sector is 34 percent in U.S., 32 percent in United Kingdom, 37 percent in Germany, 45 percent in France and Italy.

growth and economic incentives. It significantly determines the growth performance and that knowledge could be interpreted as an accumulation of R&D activity outcome. It is useful then to note that knowledge is of two types, codified and tacid. Codified knowledge is not enough to transfer the whole knowledge between agents. Tacid knowledge should also be transferred, but it is relatively difficult and costly. Finally, Keely and Quah agree on the trade side of the endogenous growth theory. Open trade regime provides an efficient environment for knowledge spillovers.

2.2 Alternative Allocation Mechanisms for Innovative Activities

As mentioned before, innovative activities have some peculiar properties. They are risky, difficult to appropriate and indivisible. All these properties complicate the optimization problem of resource allocation in these activities. Patent system regulates innovative activities to a certain extent. Clearly, patent system allows the inventor to appropriate from his inventions, and reduces uncertainty. However, overall performance of the system is still controversial and considered as the second best. Moreover, as Arrow (1962) indicates, both competitive and monopoly firms underestimate the social value of an invention, thus government intervention may be required to achieve optimum resource allocation for innovative activities, especially in the basic research.

There are several alternative solutions for the resource allocation problem at hand. Namely, government financed research projects, universities and other nonprofit research institutes are considered as other alternatives of the patent system. However, each of these institutions has some deficiencies. Patent protection system does not generate enough investment for invention, but the question "how much additional investment is required" cannot be easily answered. Moreover, there are many research areas, that is to say, not only the amount of additional research but also the distribution of investment is important. In this framework, as Nordhaus (1969) points, misallocation may cause larger welfare cost than underallocation.

Government support or warranty may also reduce the efficiency of research activities. Private commercial incentives are higher than incentives in government financed research activities in average. Moreover, research activities are undeterministic in character. The following table compares alternative forms of economic organization in innovation.

Table 2.1. Evaluation of Alternative Forms of Organizations

Criteria \ Alternative Organization	Patent System Individual / Large Firms	Government Financed R&D	Nonprofit Organizations	Academic Institutions	Research Ins. Financed by Indust.
Resource Availability	low / high	high	medium	medium	medium
Industry Coverage	high / high	medium	medium	medium	low
Optimal Allocation Prob.	low / low	high	medium	low	low
Certainty	medium/medium	high	medium	medium	medium
Degree of Spillover Effect	medium / low	high	high	high	medium
Inventive Step	low / medium	high	medium	high	medium
Ease of Administration	medium / high	low	medium	high	high
Efficiency	high / medium	low	medium	medium	medium
Economies of Scale	low / high	high	medium	medium	high

Table 2.1. reveals the following results:

- Resource availability is high for large firms under patent protection and government financed research projects, however it is low for individuals under patent system. This denotes that, individuals should be supported and encouraged in inventive investments.

- Industry coverage is high for both large firms and individuals under patent protection, but it is low for research institutes financed by government. Patent system is applicable in all industries with minor discrepancies, however government financed research projects generally cover only limited parts of the industries, namely they focus on health care, defense and pure scientific studies.

- Economy wide optimal allocation probability is low for large firms and individuals under patent protection, and academic institutions, since they have limited perspective about the social gain of inventions, but government financed researches are at least theoretically aware of the whole social return, hence achieve optimum allocation.

- Certainty is high for government financed research projects, that is to say there is little uncertainty about the outcome of these kinds of activities.

- Degree of spillover effect is high for government financed research projects, nonprofit organizations and academic institutions, but it is low for large firms. This shows that large firms prefer to internalize the possible spillovers of their inventions in order to keep valuable information away from their rivals. Patent system, unfortunately, could not force private firms to reveal whole information behind their invention. On the other hand, government financed research projects, nonprofit organizations, and academic institutions generate large spillovers, since they do not concern profitability as much as commercial firms.

- Inventive steps are high for government financed research projects and academic institutions, however they are low for patent system in average. In fact, patent system displays large divergence among individual patents. There are some patents, which have millions of dollars commercial value, but most of them are almost valueless. Therefore, an average patent can be considered as a limited step over the state of the art technology among millions of patent grants. On the contrary, academic or government financed research projects generally yield large steps over the existing technology level.

- Administration mechanism is relatively easy for patent system, academic institutions, and research institutes financed by industries, but it is difficult for government financed research projects. Academic research activities have their own autonomy, and patent system is regulated by law, this means that the administrations of both of them do not bear much problem. On the other hand, patent litigations are sometimes difficult to solve.

- Patent system is better than other forms of organizations from the efficiency point of view, since allocated resources are optimally utilized, but government financed research projects are subject to misuse.

- Large firms under patent protection, government financed research projects, and research institutes benefit from their large economies of scale, since they execute many projects simultaneously and they have generally large research budget. Unfortunately, individuals in patent system may suffer from their low scales.

Finally, it should be mentioned that, there are large deviations in practice from theoretical approach of each form of organization.

Different institutions are also studied by Nordhaus (1969) , who is one of the pioneers of theoretical patent studies. He states that the price system is unable to generate new knowledge efficiently. Patent system, government financed R&D, subsidy to R&D inputs, academic institutions, nonprofit organizations are some alternative solutions[33] for efficient knowledge generation, however all of them are incapable to optimize society completely. According to Nordhaus, investment on knowledge generation is difficult to appropriate and inventive activities have increasing returns, which complicate the problem. Patent system creates monopoly power for inventors for a given period of time, which distorts product markets. Moreover, inventors try to keep key points of their inventions and patent system may not effectively force them to reveal. On the other hand, R&D subsidy and other awarding methods are difficult to administer, since knowledge is an intangible asset and true value of knowledge cannot be determined in all cases. Moreover, such a system may create lobbies of rent seeking parties. In any case, Nordhaus models a knowledge generation system and evaluates two alternative methods, namely patent and government subsidy systems.

Nordhaus concludes that, patent system is an optimum solution for only small inventions. On the other hand, government subsidies for R&D is more efficient in the case of drastic technological achievements. Moreover, Nordhaus indicates that, optimal patent length is sensitive to the size of inventions, more progressive industries require shorther patent length and longer patent length is socially beneficial in the lower elasticity of demand case. The model also implies that increasing size of inventions causes decreasing efficiency of patent system.

Nordhaus compares the patent and subsidy systems in four main contexts, namely appropriability of innovation, differences in industries, knowledge spillovers, and

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[33] Actually, variety of institutions in R&D sector could be beneficial, since distinct sectoral needs and changing sizes of inventions require different institutional structures.

uncertainty. Firstly, Nordhaus suggests that patent system may create sufficient incentives for inventors in return of deadweight loss. On the contrary, properly administered subsidy system overcomes this welfare loss and generates enough incentives as well. Secondly, several different industries can be regulated efficiently under a uniform patent regime, however subsidy system cannot take sectoral differences into account directly. Moreover, Nordhaus indicates that misplaced subsidy spoils all aspects, and may cause high welfare loss. Thirdly, in the case of knowledge spillovers, government financed R&D or subsidy system may be designed to reveal all information. Patent system has also provisions to full disclosure of information, whereas these provisions are not forced effectively in practice. Fourthly patent system decreases the uncertainty over the commercial success of inventive activities. However, in the case of double inventors, only the first applicant receives patent grant, due to "first to file" principle. On the other hand, in government subsidy case, research activities do not bear any risk, since uncertainty is taken by government through research contracts.

In summary, Nordhaus states that, patent system is an efficient regulation mechanism for the knowledge generation process in the case of small inventions. Whereas, drastic innovation requires special treatment in order to reduce possible destructive monopoly power of patent protection. Actually, drastic inventions usually require large investments and cause large knowledge dissemination, in this sense, they should be regulated to be acquired by the public domain efficiently and immediately.

2.3 Patent System

2.3.1 History of Patent System

Intellectual property issues are subject to ongoing controversies although their existence go back to very old times. In this section, historical developments of intellectual property rights, especially patent system is studied, in order to comprehend the reasoning behind modern patent law and intellectual property concept. In the history, firstly the concept of intellectual property arose, then the basis of patent system is established, and finally copyright protection is constituted. Generally, patent system is related to inventive activities in machinery, warfare, construction, and handicraft, on the other hand, copyright protection is connected to authorship in literature and ownership in printed materials. Historically, novelty concept precedes originality concept.

Intellectual property is a legal concept, which arises from various kinds of intangible property. Intellectual property issues have been related to craft knowledge and practice, invention and authorship in writings in history. Improvements in craft processes and development of technological innovations constitute intangible properties with commercial value that are separate from concrete products. Intellectual property protection, provide a legal framework for inventors that they enjoy temporary monopoly power of their exclusive rights. Today's modern intellectual property systems have two distinct concepts namely patents and copyrights. In history, patent system covered inventions in warfare, machines, handicraft, etc. But literary studies and writings were dealt with differently although they were not explicitly defined as today's copyright protection. In any case, coverage of patent and copyright protection is somewhat similar both in today's and old intellectual property right systems.

As a starting point, the meaning of patent is investigated. Basically, it is an English adjective, which means "open" and its root comes from the translation of Latin "litterae patentes". Patent means simply "open letters" as a word. The word patent stands for the official certificate, which provides certain privileges, rights, ranks or titles that are publicly declared. Roughly, patent system is used by sovereigns as an instrument to induce the transfer and disclosure of foreign technologies, to promote further technical research, and to keep control of domestic knowledge within the domain of sovereigns. David (1993) argues that, ancient patent system's major aim was to promote technology transfer, rather than to stimulate domestic inventive activities.

In fact, as David indicates, legal institutions, like the patent system, evolve incrementally. They generally preserve many major aspects of its historical roots. Thus, although the history of patent system is full of redefinition and reinterpretation in response to pressures to accommodate or advance the economic interests of those most affected by the laws, many of the patent system's major features continue to reflect the historical heritage in which they originated. This historical heritage needs far more study since it has a complex background. In this section, the parallelism between the recent patent system and its ancient equivalent is also going to be indicated. Moreover, as new technologies arise, and world economies develop, the patent system or intellectual property concepts continue to evolve. Therefore, historical investigation of patent system might be valuable to understand the current and future structure of it.

It is clear that, positive valuation of knowledge is a prerequisite condition for protection of knowledge. Historically, positive valuation of knowledge goes back to mid 5^{th} century B.C. At that time, all commodities were produced manually, and manual work was associated with slave labor. Although society's intellectual potential was not directed to productive activities, craftsmen used to improve their production techniques by learning by doing. For example, during the late 6^{th} - early 5^{th} centuries B.C., Ionian poet and philosopher Xenophanes wrote that "Not all things, by any means, did the gods show to mortals: rather as time went on, men found improvement by constant searching". In addition to Xenophanes' writings, the Hellenistic inventor and author Philo of Byzantium in late 3^{rd} century B.C. emphasized gradual experimental progress of architecture, in which proper proportions of buildings had been discovered by trial and error. Anaxagoras, an Athenian philosopher, indicated that humans are distinguished from other living beings with their capacity for developing arts and crafts. These examples reveal that ancient civilizations were aware of the fruits of research and knowledge. Philo was also aware of the incremental nature of innovations. According to him, each new invention and writing was benefiting from existing knowledge and experiences of previous inventors. This observation is absolutely agreed on today, and most of the patent applications take existing patents as reference.

However, emergence of a fully developed intellectual property concept did not occur until the 12^{th} and 13^{th} centuries during the medieval period. Before that time, authorship and ownership concepts were weakly applied, for instance, for all of antiquity once the first copy of a book had been made and distributed, its fate was beyond the author's control. There was no legal system to protect the integrity of the book, limit the number of copies, or impede imitation of a new technology. Naturally, there were some exceptions; namely Vitruvius, a Roman architect and military engineer, paid attention to credit previous authors and inventors. According to him, the theft of writings and inventions should be banned. Interestingly, Vitruvius' care was not a commercial or benefit oriented effort, rather it only arose from individual reputation seeking. Actually, there is little evidence that either writings or inventions were viewed as commodities with a marketplace value in the ancient world. Authorship was supposed to bring immortal fame, so theft in writings spoils the author's reputation and fame. Pliny, a Roman writer in the 1st century A.D. also insisted that authors should receive credit for their contribution and work. According to him, like Philo, knowledge accumulation was a cumulative process, and crediting original authors and inventors would increase the creation of new knowledge. At this point, Long determines that this ancient intellectual property concept had two important missing parts. Namely, it was not differentiated from tangible goods and it had no commercial characteristics. That is to say, ancient intellectual property concept did not deal with commercial care, and it was mixed with tangible commodities.

Fully developed concept of intellectual property emerged with the arise of the medieval cities and the market economies that developed within and among them. The concept is first evident within the regulation of the craft guilds into which many urban artisans had been organized by the mid-13th century in Venetian society without ever calling it. The development of guilds, which were organizations of artisans based on particular crafts and technologies, is a crucial milestone in the history of intellectual property rights. Actually, in the ancient times, the primary purpose of the guild system was mainly social solidarity. On the contrary, medieval artisan guilds had also some economic functions such as, protecting craft, improving and perfecting production techniques, and organizing apprenticeship system. That is to say, the market economies, that developed within medieval cities in Europe, provided the essential atmosphere for the emergence of a fully developed intellectual property concept. The medieval craft guilds significantly developed proprietary concept of craft knowledge. The guilds promoted the ownership of intangible property in the form of craft knowledge which was distinct from material products. For example, the guilds permitted the export of Venetian glass products, which were the finest glass in Europe, but the export of the craft itself was strictly forbidden. The view that craft knowledge was intangible property with commercial value developed in this context, quite apart from notions of individual authorship. The Venetian society considered that; craft knowledge was communal property and knowledge should be used for the benefit of Venice. In this sense, private ownership character was missing in early Venetian system, therefore intellectual property rights protection provides only communal motivation for innovation. The development of the patent system is based on the fact that medieval urban economies try to maintain the control over the crafts, to possess the benefits of new craft knowledge and to encourage further innovations. Clearly medieval craft guilds were aware of commercial value of their knowledge and they differentiated it from tangible commodities.

Basically, in medieval Europe, inventions were also awarded by sovereigns to foster further innovations and technology transfer. As historians stated, these motivation efforts were in some way successful. Nevertheless, this should not be interpreted as a well defined and established IPRs protection system. Actually patents were granted for inventions in Europe in 1443. The first official IPRs system was born in Venetian Republic in March 19^{th}, 1474, which was known as "Inventor Bylaws". This law is considered as the oldest text of patent system and required that every invention should be applied to officials. The patent protection duration was 10 years in this law. This Venetian law included some sanctions against infringements. Practically, the limited protection period and the sanctions against infringement concepts are similar to today's patent laws' provisions. The infringer might be obliged to pay fine and his imitations could be destroyed. In the case of infringement, the case could be reported to city officials, and if it was verified, then the infringer could be fined. This reporting mechanism is also similar to its modern counterpart. On the other hand, Venetian Government had the right to use the invention without permission. During these periods and before, secrecy was also used as an alternative for patent protection, especially outside of Venice. However, patent system was used more widely in the 16^{th} century.

Long (1991) states that, the main interest in patent system was aiming to promote the economies of cities and encourage importation of useful inventions from foreign countries. Long gives examples, that Venice society awarded patents to both Venetians and foreigners. By this way, Venetians encouraged transfer of new technologies into their economy and kept their commercially valuable production technique and knowledge within Venetian society. According to Long, Venetians were aware of the commercial value of their inventions and products, so they tried to protect this value not only inside, but also outside their country. By this way, they contributed to the constitution and spread of patent system. As Long indicates, "In England, for example, Jacobus Acontius, an Italian inventor, petitioned Elizabeth I for a patent with an explicit justification that a patent grant should be an award for inventors." Long quotes J. Acontius's petition as follows: "Nothing is more honest than that those who by searching have found out things useful to the public should have some fruit of their rights and labours, as meanwhile they abandon all other modes of gain, are at much expense in experiments, and often sustain much loss, as has happened to me."

The main reason of the emergence of this IP concept and its protection in medieval Venetian society, was taking control of knowledge. On the other hand, according to David, as mentioned above, the major aim was to promote technology transfer from abroad in order to reach foreign technology level. In this sense, there is a clear strong correlation between today's foreign direct investment (FDI) promoting IPRs protection regime and its ancient equivalent. Although it is not proven, it is generally believed that strong IPRs protection induces technology transfer from foreign countries as a FDI. David gives examples to support his argument; "Letters patent were given to the Flemish weaver John Kempe by Edward II in 1331, to two Brabant weavers to settle at York in 1336, and to three clockmakers from Delft in 1368." According to David, England was technologically underdeveloped with respect to continent of Europe in early 14th century, so foreign craftsmen and artisans were granted for patent rights in order to catch up with continent of Europe's high technology level. In fact, in the 14th century, patents were used to encourage the immigration of skilled artisans from abroad. Domestic originality of use in England was a sufficient condition to be eligible to patent grant at that time. In this way, technology transfer was somewhat successfully achieved. Trade secrets were the most widely used form of intellectual property protection before the introduction of patent system, since masters were not willing to reveal their know-how to potential competitors. Trade secrets helped to ensure the privileged status of the master - apprentice relationship and of the craft itself. There were two types of secrecy in crafts knowledge. The first type was "secrets of nature" and the second type was "intentional concealment". Patent system intended to eliminate the second type of secrecy, by protecting masters and instructors from the competition[34] of their potential rivals and students, by giving them a limited monopoly power of production and trade. In this sense, the disclosure provisions of today's modern patent system arose from essential aspects of the efforts to induce foreign artisans to reveal their secret knowledge about crafts. These early English patents were 14 years long and had 7 years extension option. David explains the reasoning behind these protection periods, 7 years period was supposed to be the duration of apprenticeship, so patent system provided at least two generation of trainee long protection. During this era, the originality, novelty and nonobviousness were not binding criteria, in fact major concern about granting was based on the requirement that the invention should be unknown within the sovereign's or guild's domain. Absence of these three criteria, are the primary differences between ancient intellectual property concept and its current counterpart[35]. David indicates that, constitution of these three patentability requirements took 200 years long struggles. Most historical studies determine that the origins of systematic state protection of intellectual property arose from Renaissance Italy, from where it spread first to the continent of Europe and later to England. David states that: "As early as 1332 the Venetian Grand Council established a privilege fund for providing loans and other rewards for a foreign constructor of windmills who offered to bring knowledge of this art to the city. In 1416, the council awarded Franciscus Petri, from the island of Rhodes, a patent for a superior device for the filling of fabrics, which gave Petri and his heirs exclusive rights for 50 years to build, alter, and reconstruct the apparatus he would erect for that purpose".

In the history of intellectual property, Venetian Republic and Britain do have the longest continuous intellectual property protection traditions. In Britain, its origin can be traced back to the 15th century, when the crown started making specific grants of privilege to manufacturers and traders. After the Venetian patent law, further developments were achieved in England. In 1624 "Monopoly Act" which defined

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34 Obtaining a patent can reduce or eliminate this competition because it gives the inventor a temporary monopoly to produce his invention. It thus helps to ensure a reasonable economic return to inventive activity. Patent system provides an important incentive to engage in research and to share its outcomes.

35 Although today a small number of countries' patent law requires only national novelty, this cannot be generalized to whole current patent regimes.

basic concepts of patents, was enacted. Section 6 of the law states that "for the term of 14 years or under hereafter to be made of the sole working or making of any manner of new manufacturers within this Realm to the true and first inventor". The governments aimed to encourage economic developments through new inventions and processes by using patents. When an inventor gets a patent grant, he also gains additional benefits, for example tax exemptions, to promote research activities. Monopoly Act is still influential on today's systems.

In 1790, America enacted its own patent law by stating that "in order to promote progress of useful technology and sciences, the parliament shall grant limited exclusive rights for a certain period of time to inventors" after the independence. Modern American patent law is constructed on this old provision. During the 18th century, American system was mainly attaching importance to technology transfer side of patent system rather than indigenous invention. In fact, American patent system has heavily inspired with English and French patent laws. Next step came from France in 1791. In the initial French patent law, there was no examination requirement. Naturally, absence of examination weakens the patent law. The first mandatory examination system was constituted by Germany in 1877.

In summary, intellectual property protection, especially patent system are regarded as public policy instruments that should be designed to enhance economic development level by fostering inventive activities. In this section, historical roots of intellectual property rights protection is briefly investigated. By doing so, it is aimed that the primary motivation behind the system can be identified. Actually, allocative efficiency in inventive activities and distributional issues are still the major economic policy problems of today's modern economies. In this context, it can be concluded that, modern intellectual property rights protection regimes give great weight to its precedent. In fact this is not surprising, since institutional evolution demonstrates incremental changes through time. On the other hand, as the nature of technologies changes, the system will further evolve. In short, the rise of patent system is heavily influenced by the two primary economic aims of old civilizations. Firstly, these civilizations were aiming to transfer technology from developed foreing countries, and secondly medieval artisan guilds were trying to keep commercially valuable craft knowledge within their domain. In this sense, promoting further technological developments locally can be considered as a secondary aim. This point may shed light on the ongoing controversies betweeen developed and developing countries about the stringency of uniform intellectual property rights protection. Historical investigation about the rise of intellectual property rights and patent system, do not reveal whether the system is economically beneficial or detrimental.

2.3.2 Description of a Patent System: The U.S. Patent Law

In the previous section, historical development of the concept of intellectual property rights, and especially patent system is investigated. In this section, one of the most advanced and stringent modern patent systems, namely U.S. patent system[36], is analyzed. The major aims of this analysis are to describe the patent system in general, identify the patentability of inventions, determine barriers for issuing a patent grant, and investigate what a patent grant provides to the owner.

Inventions[37] are key to a prosperous and developing society. They help to work better, to make finer products and to compete more effectively in world trade. Information diffusion and exchange of ideas are as important to all economies as the flow of money or goods and services. To promote this exchange, while protecting owners' rights, legal authorities consider certain kinds of creative activities subject to patent protection. Inventors can receive legal recognition for these activities in much the same way as anyone receives title to a piece of land. In addition, the records and the documents that protect intellectual property owners' rights contain valuable information. Much of it is available to the public and may be useful in many ways.

Shortly, patent can be defined as a contract between the government[38] and an inventor, providing that, in return for full disclosure of the subject matter within the

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[36] Title 35 of U.S. Code, Patents, describes the functions of Patent and Trademark Office (USPTO), patentability of inventions and grant of patents, patents and protection of patent rights, and finally relationship with Patent Cooperation Treaty (PCT).

[37] The invention can be defined as the active combination of presently known elements into a new form. The invention term is closely associated with discovery, since discoveries often lead to inventions.

[38] U.S. Patent and Trademark Office is entitled to perform necessary actions in this contract on behalf of the U.S. Government.

invention, the government grants the inventor an exclusive right to practice the invention for a predefined period of time. During this period, owner of the patent has the right "to exclude others from making, using, or selling the invention throughout the United States." When a patent is granted, the invention becomes the property of the inventor, which - like any other form of property or business asset - can be inherited, bought, sold, rented, hired, mortgaged and even taxed. These rights are granted by United States federal patent law, which provide exploitation of ideas, and inventions. Patent rights are territorial; a patent will only give the holder rights within United States and its possessions, and rights to stop others from importing the patented products into the United States. Global protection requires application in all countries. Title 35 of U.S. federal law deals with Patent Cooperation Treaty (PCT), which is an agreement on multiple international patent application.

In this sense, patents can be considered as negative rights; that is, rights to stop anyone else from benefiting from an invention. Therefore anyone who is thinking of manufacturing a product or putting a process into operation should first check whether he would be stopped from doing this by a patent in force, that is still legally enforceable. Even if an inventor creates a product or a process that is new, and obtains a patent for the invention, this check is still necessary since the obtaining of a granted patent does not mean that the patent holder is automatically free to carry out the invention. Ignorance that an applicant is infringing someone else's patent has no defense. Patent applicants should try to find out about existing patent grants. Alternatively, an inventor can choose to let others use it under agreed terms. A patent also brings the right to take legal action against others who might be infringing the invention and to claim damages. The mere existence of a patent may be enough to deter a potential infringer. The United States Patent and Trademark Office, however, does not take sides in any dispute. A patent empowers the owner of an invention to take legal action against others to prevent the unlicensed manufacture, use, importation or sale of the patented invention. This right can be used to give the proprietor breathing space to develop a business based on the invention, or another person or company may be allowed to exploit the invention and pay royalties under a licensing agreement.

The patent protection system is beneficial not only from inventors' point of view but also from the public point of view, because the society gains advanced knowledge of technological developments, which they will eventually be able to use freely after the patent expires. At the end of the protection period, the patent becomes public property available to all. However, the grant of a patent does not guarantee the owner with the full legal right to commercialize the invention, since commercialization may require the use of other technologies, which are patented, and thus owned by someone else.

Patents are granted to encourage inventors to disclose their inventions to the public and thereby to "promote the progress of science and useful arts." In fact, U.S. Constitution[39] empowers the Congress to define and confer these rights to authors and inventors for their respective writings and inventions. In the United States, the federal patent law protects any "new and useful process, machine, manufacture, or composition of matter, or any new and useful improvements thereof" which could not "have been obvious at the time of the invention".

The United States patent law provides the granting of patents in three major categories, namely utility, design and plant patents. Utility patents are granted to anyone who invents or discovers any new and useful process, machine, manufacture or composition of matter, or any new and useful improvement thereof. Process means a process or method; new industrial or technical processes may be patented. Manufacture refers to articles, which are made. Composition of matter relates to chemical compositions and may include mixtures of ingredients as well as new chemical compounds. Design patents are granted to any person who has invented a new, original and ornamental design for an article or manufacture. The appearance of the article is protected. Plant patents are granted to any person who has invented or discovered and asexually reproduced any distinct and new variety of plant, including cultivated sports, mutants hybrids, and newly found seedlings.

2.3.2.1 Patentability Conditions

Patent system covers both inventions and discoveries, which are useful, novel and non-obvious. Both products and processes are eligible to be granted. Patents are

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[39] See provisions of Article I, section 8 for details.

generally intended to cover products or processes that possess or contain new functional or technical aspects; patents are therefore concerned with, for example, how things work, what they do, how they do it, what they are made of or how they are made. The vast majority of patents are granted for incremental improvements in known technology; it has been said that innovation is evolution rather than revolution. Title 35, section 102 of the U.S. Code provides the conditions of patentability. According to this section, a patent can be granted unless "the invention was known or used by others in the United States, or patented or described in a printed publication in the United States or a foreign country before the invention thereof by the applicant" or "the invention was patented or described in a printed publication in United States or a foreign country or in public use or on sale in United States more than one year prior to patent application." These conditions identify whether the invention is novel or not.

An inventor is not required to get a patent in order to put an invention into practice, but once the invention is made public, there will be no protection against others using the invention. The granting of a patent should not be taken as any indication that an invention has any merit or commercial value. Naturally commercial success of any invention cannot be obtained by a patent right only. Moreover, it is not possible to guarantee that a patent, once granted, is valid. Anyone can apply to the court or the patent office for revocation of a patent for reasons that are laid down in the patent law. If the person succeeds, the patent must be revoked entirely, or be amended to remove the reasons for revocation.

Inventions and discoveries must contain non-obvious subject matter in order to be patentable. Section 103 of the U.S. Code states that "if the differences between the subject matter sought to be patented and the prior art[40] are such that the subject matter as a whole, would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." Clearly, the non-obviousness condition requires that an invention represent more than a trivial step over the state of the art. According to Gutterman and Erlich (1997), this condition can

[40] Knowledge is available to the public either prior to the invention by applicant or more than a year prior to the effective filing date of his / her application.

be interpreted as follows, invention should be non-obvious to a person[41] of ordinary skill in the art. A scientist working in the field, however, can be considered as highly skilled, so can exceed the requirement. In fact, this criterion remains open to misinterpretation. Moreover, stringency of non-obviousness conditions heavily affects the scope of patent rights. For example, weaker standards of non-obviousness relax patentability requirements. Generally, as patentability criteria are relaxed, a larger number of patents will be granted in the same field of technology, therefore the scope of patent rights will be narrowed. Conversely, stringent non-obviousness requirement increases the scope of a patent right. An invention does not have to be a basic process, machine, article of manufacture or composition of matter to obtain a patent. Conversely, an improvement on a previously patented process, machine, or composition of matter, or an unobvious combination of old elements may also be entitled to patent grant.

An invention is not patentable if it is: a discovery, a scientific theory or mathematical method, an aesthetic creation such as a literary, dramatic or artistic work, a scheme or method for performing a mental act, playing a game or doing business, the presentation of information or a computer program. If the invention involves more than these abstract aspects so that it has physical features (such as a special apparatus to play a new game), then it may be patentable. In addition, it is not possible to get a patent for an invention if it is a new animal or plant variety; a method of treatment of the human or animal body by surgery or therapy; or a method of diagnosis. The invention must not be contrary to public order and morality. In the United States, computer programs are eligible to get a patent grant, but this is not possible in other countries. In addition to these technical barriers to get a patent right, sometimes the inventor himself loses his right by using or selling the invention prior to the effective filing date of a patent application.

Although Title 35 U.S. Code 101 indicates the type of subject matter, which can be patented, specific interpretation of this section of the statute is left to the courts. On the other hand, as technology changes, the scope of the subject matter upon which a

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41 This hypotetical person is assumed to know all of the relevant prior art.

patent can be granted also evolves. United States patent law was amended several times in order to handle technological developments.

2.3.2.2 Patent Application

Patent applications can be performed by only true inventors or his (her) patent attorneys. A draft of the patent application will be prepared, when the decision to file a patent application is made. All applications have to be made in written to the commissioner. A complete patent application should contain a specification including at least a claim, necessary drawings, an oath, and a filing fee.

The specification should contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any skilled person in the related field of technology to make and use the same invention in its best mode. If the inventor had specific processes, techniques, compositions, material or conditions that he or she recognized at the time of filing as the best way of carrying out the invention, then he or she must include that information in the patent disclosure. The purpose of this requirement is to ensure that a patent applicant acts fairly with the patent system. An inventor must disclose his or her best mode to the public in exchange for patent protection. Actually, full disclosure requirement may be also beneficial for the applicant himself. Since as Gutterman and Erlich stated "If there are any doubts whether or not information should be included in the detailed description of the invention, they should generally be resolved in favor of including that information. Failure to include the information often raises serious legal implications, since if the information is later required by the Patent and Trademark Office, its insertion within the specification may be considered as new matter and this newly inserted information will therefore not be given the benefit of the filing date of the original application and the Patent and Trademark Office will require that the information be stricken from the application. Such additional information can thereafter only be inserted by filing another application, referred to as a continuation-in-part application. However, in such a continuation-in-part application, the inventor also loses the benefit of the early filing date with respect to the new information". The specification should conclude with one or more claims[42] which point out clearly the subject matter of the invention. The necessary drawings should be included in the application documents. The major aim of the drawings is to explain the invention in a better form. Specification section should reference the drawings. In the oath, the inventor must declare that he or she understood the contents of the specification(s) and he or she is the original, first, and sole inventor[43] of the invention. Moreover he or she must also declare that, all the necessary information is disclosed in the application. The inventor should also state of which country he is a citizen in the oath section.

When an invention is made by two or more persons jointly, they should apply for a patent jointly and each should make the required oath. Inventors may apply for a patent jointly even though they did not physically work together at the same time or each did not make the same type and amount of contribution.

United States patent system allows provisional patent applications[44]. Provisional patent application system permits the establishment of an initial effective filing date without spending from twenty-year term of patent protection. The provisional patent application must contain a specification and any necessary drawings in compliance with Title 35 U.S. Code 112, and filing fee, but does not have to contain oath, like a regular application. The provisional patent applications are kept secret in the patent office, and will not be examined. The provisional applications expire within twelve months from the date of its file. Regular patent applications should be made within these twelve months, then patent examination will be performed.

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[42] Claims are the numbered sentences appearing at the end of the patent and define the invention. The words of the claims define the scope of the patent owner's exclusive right during the life of the patent.

[43] Joint invention and application are also allowed.

[44] The provisional patent application is a form of preliminary patent application, which can be filed at a lower cost and without claims and certain other formalities.

2.3.2.3 Examination of Patent Applications

Title 35 U.S. Code 131 - 135 describes the examination procedure of a patent application. Each patent application shall be examined by a patent examiner[45], if such an examination concludes that an application satisfies the patentability requirements, then the commissioner shall issue a patent therefore. Gutterman and Erlich indicate that, the patent application generally waits for approximately one or more years before being examined by a patent examiner in the United States Patent and Trademark Office. Patent applications are examined in order of its filing date, with the application having the earliest filing date being examined first. During the whole period of examination, the application is kept confidential regardless of its status. Only government personnel and persons authorized by inventor are permitted to access the file of the application. The inventor can use, produce, or sell his or her invention during the examination period. Moreover, the inventor can place a "patent pending" sign on the invention. However, this can only be done in regular patent applications, provisional applications cannot be signed. Naturally, examination period does not provide a legal protection, since legal protection for the invention is obtained only when the patent is issued.

After initial processing stage, which may take 6-9 months or more, a patent examiner will review the application and write a letter[46] commenting on it. The first aim of the patent examiner is to determine whether the claims are patentable and whether the specification adequately describes the invention claimed. In examining a patent application, the patent examiner makes a search of the office's patent records and other available foreign resources for prior art to the patent application claims. The examiner considers whether each claim defines an invention that is original, useful, and not obvious in view of this prior art. Following the prior art search and examination of the application, the patent examiner then advises the applicant in writing what he has found and whether applicant's claims are allowed. The first Office

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[45] Personnel, employed by the Patent and Trademark Office who examine patent applications, each in a specific technical area, to determine whether the claims of a patent application are patentable and whether the disclosure adequately describes the invention.

[46] This letter is called as Office Action. Office Action can be defined as communication from the patent examiner regarding the specification of the patent application and/or the claims pending in the patent application.

Action often is a refusal[47] to grant the patent, and the applicant then may modify the application to overcome the objection of the examiner. The patent attorney will reply in writing to the Office Action, usually making some changes with the help of the inventor and submits new or modified claims. This process may go back and forth between the patent examiner in the Patent and Trademark Office and the applicant until the examiner is satisfied, or the application is withdrawn. Typically, at least two such exchanges between patent examiner and attorney are necessary to resolve all the legal and technical issues. These exchanges and initial processing take an average of about 18-22 months from filing date.

When the examiner is satisfied that the application is in proper form and its claims are allowable, the applicant is notified that a patent grant will be issued upon the payment of final fees. In order to keep the patent in force until it expires, it is also necessary to pay progressively higher maintenance fees at 4^{th}, 8^{th}, and 12^{th} years of the patent life. The major aim of this progressive fee schedule is to eliminate the commercially unsuccessful patent, and force the commercialization of the invention.

2.3.2.4 Exploitation of Patent Grant

As mentioned before, patent is a document, which constitutes exclusive rights for the owner like any other properties. The owner of a patent may protect his / her exclusive rights embodied in the patent grant against infringers by performing legal actions. If these rights are effectively protected by the owner and the law, then they provide some opportunities of strategic uses of patent rights. Fundamentally, like other forms of properties, patents can be sold, rented, or mortgaged depending on the owner's choice. Naturally this choice is shaped by several external effects, namely financing and production skill of the owner[48], existing market structure for innovative products, and supportive institutions for inventions. Most inventors seek a patent to obtain the actual or potential commercial advantages over their rivals. Given the high cost of

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47 One recent study found that, at least 72 % of all the claims are either amended or canceled. See Wayne O. Stacy, Note, Reexamination Reality: How Courts Should Approach a Motion to Stay Litigation Pending the Outcome of Reexamination, 66 GEO. Wash. L. Rev. 172 (1997).

48 A commercially successful invention requires not only new idea, but also competent business skills and capital investment. To be successful, an invention (patent) usually needs a coordinated business planning, manufacturing, marketing, and sales effort.

research and development, the opportunity to recoup these costs through commercial exploitation may be the primary justification. It is important to note that a patent does not give the owner the right to practice the invention. The owner can practice his invention only if by doing so, he does not infringe the existing unexpired patents.

Basically the patent owner has five alternative exploitation forms. In the first alternative, the owner renounces from his or her rights and adds his invention to the public knowledge domain, which can immediately be used freely. Naturally this alternative can be obtained without any patent grant. Secondly, the patent can be used to induce domestic and foreign inventors to finance the necessary investment for the commercialization of the invention. This alternative is reasonable in the case where the owner does not have enough financial and production capabilities. Effective patent protection, even limited period of time, provides fruitful term for the investors.

In the third alternative, the owner may exploit his patent himself when he has sufficient financial and productive skills. Obviously this is a rare case, since full commercialization of an invention may require a large amount of investment. Employee patents may be considered as this kind of exploitation theoretically. Many of the high technology firms, which have hired inventive and skilled employees, provide some benefits as compensation in return to use their patent rights. It should be noted that the patent concept is essentially individual property, that is to say it must be designated to an inventor or inventors jointly.

However, large firms have thousands of patent grants as a firm asset, since the shop right concept grew out of judicial concerns, that employees were taking unfair advantage of their employers and that equity necessitated that employers be protected. As a result, the patent law prevents employees from claiming infringement on the part of employers, when the work done on a patent comes out at the expense of the employer's time or materials, necessitating that the employer be offered certain rights in the patent. In fact, in the case where no valid written agreement exists between the employee and the employer assigning ownership of the invention to the employer, three general common law principles apply: (1) If an employee is not hired specifically for the purpose of inventing anything, then whatever he or she may invent during the course of the employment will be owned by the employee. No implicit agreement to assign any patent to the employer arises. This general rule applies even if the invention is related to the employer's business. (2) When an employee is hired to invent, but the employer has no more in mind than a desired result and does not give the employee instructions as to the means the employee must use to accomplish the particular result, then any resulting invention, even if related to the employer's business, will again be owned by the employee. (3) If an employee is hired to create a specific invention and the employer can demonstrate that the means to bringing the idea into practical form were clearly spelled out for the employee, the employer will be deemed the owner of the invention where the invention is within the scope of the inventor's employment and relates to the employer's business. Even in the first two scenarios, where the employee owns the invention and any resulting patent, the employer may have a "shop right" to the invention. A shop right is an employer's non-exclusive, royalty-free, non-transferable license to make, use and sell items embodying an employee's patentable invention, but only within the normal scope of its business. A shop right doesn't automatically arise, however. It typically exists only where an employee has used the employer's time, materials or equipment in creating the patented invention. A shop right can last beyond the employee's term of employment, but it expires along with the patent at the end of its 20 years long protection term. Technically, a shop right is not an ownership right on the patent, but is a defense against an employee's allegation of patent infringement.

Fourthly, if the owner is unwilling or unable to commercialize the underlying invention, he can license the right to use the invention to others, in return for a royalty payment. Basically the owner may choose to transfer monopoly right over the invention in some cases. Lastly, patent rights can be utilized as a contribution to a new business enterprise, such as a domestic or foreign joint venture. Naturally, the structure of a joint venture enterprise depends on domestic and foreign laws of investment and patent. Finally, it should also be noted that, there is difficulty in almost all forms of strategic use of the patent rights, except self-commercialization, since all forms of contracts, namely licensing, joint venture etc. may bear high degree of asymmetric information about the invention between the inventor and the contractor.

2.3.2.5 Infringement of Patent Rights

Title 35 of the U.S. federal law also deals with the infringement concept and remedy for the infringement. A person or company is said to be infringing on claims of a patent when they, without permission from the patent owner, make, use, import, offer to sell, or sell the patented invention, as defined by the claims, within the United States, its territories or possessions, before the term of the patent expiration. A person who actively induces infringement of a patent shall be liable as an infringer. A contributory infringer can be defined as a person who offers to sell or sells a patented product within the United States or imports a patented product into the United States. If there is no direct infringement by anyone, there can be no contributory infringement.

Infringement is generally classified as either direct or indirect. A direct act of infringement is the actual use, or commercialization of the invention. Indirect infringement act refers to acts by persons other than a direct infringer. Direct infringement can be in two different forms, namely literal infringement and doctrine of equivalent. A patent claim is literally infringed only if defendant's product or process includes each and every element or process in that patent claim. Conversely, if defendant's product or process does not contain one or more of the elements or processes declared in a claim, the claim is not literally infringed. Literal infringement must be determined with respect to each patent claim independently. Gutterman and Erlich point out that "A person need not have notice or knowledge of the patent in order to be liable for direct infringement. The simple act of making, using, offering for sale, selling, or importing the claimed invention constitutes infringement regardless of the infringer's intent and knowledge of patent." The doctrine of equivalent has been developed by courts to resolve those cases where literal infringement cannot be proved. Doctrine of equivalent form of infringement is based on the fact that patented inventions should be protected against the products, which have substantially the same function and are produced in substantially the same method. If the defendant's product or process contains equivalent of the element in the claim but not the same, this may indicate doctrine of equivalent form of infringement.

A patent owner that believes that someone is infringing on his or her exclusive rights under a patent may bring a lawsuit to stop the alleged infringing acts and recover damages. The patent owner has the burden to prove infringement of the claims of the patent. The patent owner also has the burden to prove damages caused by the infringement. If an infringement case is proved, the infringer has to cover the loss of the owner due to infringement damage. The lost profit of the patentee is based on loss of potential sales, price reduction of infringer, and loss of profits from projected sales. They are all considered in determining the extent of damages in the infringement action. Damages may not be less than a reasonable royalty for the use of the invention. This kind of remedy is only applicable in the case of appropriate notice or marking has been placed on the patented product. A person sued for infringing a patent can deny infringement. Inevitably accused party has a right to prepare his defense against the litigant. Generally, they try to prove that the asserted claims are invalid or unenforceable in order to be released from the case. The accused infringer has the burden to prove invalidity by clear and convincing evidence. In evaluating infringement or invalidity, each claim should be evaluated independently.

2.4 Theoretical Perspective

2.4.1 Welfare Analysis of Patent System

As a legal regulatory institution, patent system has welfare effects. In this section, welfare analysis of patent system is investigated. Roughly speaking, welfare effects of patent system depend on its stringency. Stringency of patent system is determined by both length and scope[49] of patent. It is generally shown that if patent length or scope increases, then patent system becomes more stringent.

Patent length determines how long patent owner can hold his/her exclusive production, selling, and distribution right. Patent law sets maximum allowable patent length. A patentee has to pay the annual renewal fee to continue to hold his right. However, a patentee can withdraw his right by terminating his payment. In this sense, patent length defines the upper bound of a policy variable in patent system. In most of todays' economies, patent laws state that patent length[50] is 20 years.

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[49] Breadth and width of patent are alternative terms that explains the scope of patent.

[50] Some authors use patent duration or patent life expressions as an alternative for patent length.

On the other hand, patent length is not the only policy variable at hand. Patent length and patent scope should be considered together. Gilbert and Shapiro (1990) studied optimal combination of patent length and scope. According to them, there is a trade-off between these two policy variables, which possively affect the reward of the right holder. They examined socially optimum policy mixture of patent length and patent scope for a given reward to patent owner. According to their interpretation, patent scope is the ability of the patentee to raise the price, which constitutes the flow rate of monopoly profit of patent. Patent length is the duration of this profit flow. Broader or longer patent generates higher reward to the innovator. Net present value of total reward can be calculated as the integral of discounted flow rate of profit over patent length. The model can be described as follows; a social welfare function which depends on the flow rate of profit is defined. Social welfare function is the sum of consumer surplus and profit terms, it is integrated over the patent length and discounted in order to find present value of it. Then the well – known optimization problem can be constructed as follows; the discounted social welfare function is maximized such that reward for invention is given. In fact, this problem does not aim to determine the optimum reward policy, it just targets optimum implementation of patent system while providing constant reward for invention. The model assumes that social welfare decreases when profit increases. Broader patents generate higher profits, but cause increasing welfare loss in terms of deadweight loss. Then the model implies that increasing patent length thus decreasing scope always raises welfare, therefore an infinitely lived patent is optimal. This result mainly depends on patent breadth's being increasingly costly in terms of deadweight loss assumption.

In summary, this model shows that narrow but lengthy patents are socially optimum. The model solves an infinite horizon optimization problem. Gilbert and Shapiro assume that patent holders are faced with a stationary and predictable environment. Their study indicates that optimal patent policy requires an infinite patent length, under the assumption that pre-determined patent reward is adjusted with the breadth of patent. Naturally, if the assumption of stationary and predictable environment is relaxed, then their results may change. Gilbert and Shapiro focus on a single invention in their model. However, this is a strong simplifiying assumption since most of the inventions depend on previously taken inventive steps. But, then, infinitely protected patent rights may generate too much disincentive for further inventive activities. In summary, Gilbert and Shapiro give a policy implication, that infinite patent length[51] is, clearly, socially optimum under the stationary, predictable and a single invention environment.

Scope of patent protection is an important aspect of patent system. Today, United States and Japan patent systems are different from each other in this respect. In Japan patent system, a minor change in the patented product is enough to issue a new patent grant. However in the United States, scope of patent protection is wider than in Japan today. Scope of patent protection and socially optimum patent policy are studied by Klemperer (1990).

Eli Whitney's 1794 cotton gin patent is a well-known and sharp example of narrow patent scope. The 1793 American patent act defined nearly zero patent width. At that time, competitors of Eli Whitney made minor modifications and granted their own patents. Therefore original invention produced very little profits. Nevertheless, modern United States patent law allows broader scope of patent. Japanese, German and English patent laws have narrow patent width with respect to American implementation. A broader patent width allows the patentee to make more profit and reduce competitors' chance to get a patent near the original invention. Therefore, scope of patent protection has direct effect on social optimization problem.

Klemperer indicates two kinds of social welfare costs, on the one hand some consumers switch to less preferred but unpatented substitutes of original patented products while on the other hand some consumers prefer not to consume due to higher priced patented product. Wider patents allow patent holders to charge higher prices, since competition is banned in the vicinity of the original patent. Two extreme cases are worth to be mentioned: infinitely wide and nearly of zero width patent protection regimes. In the first case, all consumers make socially efficient allocation between varieties of the original product, since patent covers all varieties. Infinite scope of patent generates only second kind of welfare loss; some consumers prefer to be outside the market. On the other hand, only first kind of welfare loss which indicates substitution to the less preferred alternatives, becomes important when patent is of

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51 In this sense, it is clear that Gilbert and Shapiro implicitly assume that there is no obsolescence risk for inventions.

nearly zero width. In the light of these two kinds of welfare losses, Klemperer concludes that there exists two distinct optimum solutions for the following two scenarios. In the first scenario, all consumers have the same per-unit substitution cost, so called transport cost, between preferred variety and alternatives. In this case, arbitrarily narrow and infinitely long patent protection is socially optimum. In the second scenario, all consumers value a preferred variety more than the alternatives by the same amount, which is known as reservation price. In this case, short lived and infinitely wide patent protection is socially optimum. Thus Klemperer's results suggest how optimal patent policies vary across different product types.

The major assumption of the model is the absence of subsequent inventive activities and new patents. In the model, once the patent is awarded, innovative activities are ceased. Klemperer is aware of the limitations of this assumption and proposes that further studies should be developed to include an optimal patent height[52] in addition to his theory of optimal width, since further innovations may introduce the same patented product with higher quality. Optimal patent policy should address another policy question, namely how much quality improvement is required to obtain a new patent without infringing the original patent? In summary, Klemperer suggests that there are two alternative patent shapes which are optimal for two distinct types of product demands, without dealing with the supply side of inventive activities.

At this point, investigation of empirical importance of patent scope should be beneficial. Lerner (1994) examines the relation between scope of patent and firm value, and reports a significant positive relationship using patent data of biotechnology firms. According to him, first policy variable is patent length and it is examined in detail; however scope of patent is relatively new dimension of the patent system and deserves attention. Lerner starts with the theoretical results of Gilbert and Shapiro (1990) and Klemperer (1990), then tries to estimate the effect of patent scope on firm values by using International Patent Classification (IPC) scheme.

Most patents become obsolete before the legal patent protection period ends. In today's information era, technological developments are too rapid to hold a patent commercially valuable in a long period of time. In this environment, scope of patent

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[52] Patent height is defined to determine the protection range of patent over quality dimension.

protection is more important than the patent length, nevertheless theoretical and empirical studies are not mature yet.

Lerner indicates that there has been a norrowing trend in patent scope in the last two decades. This observation suggests two alternatives: one is that increasing number of patent applications make the technology space dense, and the other is that there is increasing doubt about monopoly effects of wide patent protection. However, theoretical or empirical studies on these claims are absent up to now.

Lerner considers that case by case patent assessment is the best way to determine the value, but it is difficult and costly to apply widely. Experienced lawyers and scientists spend several weeks for a single patent assessment. Therefore, IPC scheme is evaluated as a proxy for patent scope in the study. Clearly, number of subclasses of patent classification assigned to a patent are assumed to be correlated with patent scope. The data are collected from United States Patent and Trademark Office's (USPTO) database. Two distinct patent classification schemes are used for each patent, namely U.S. and IPC. U.S. patent classification scheme is mainly based on structure and function of the invention, however IPC patent classification scheme considers profession and industry of the invention. Therefore, according to Lerner, IPC classification scheme is a more appropriate scope measure than U.S scheme. Lerner, then, validates IPC scheme as a proxy for patent scope. Finally, Lerner concludes that, there is a positive relation between patent scope and firm value. Moreover, he reports the observation that the scope of patent awards has been narrowing significantly in the last decade.

Welfare analysis of patent policy is a difficult subject to handle, since scope of patent is not directly related to its commercial value. That is to say, some patents may be fruitful for further inventions, while they have no commercial value initially. Moreover, innovation is a cumulative process and patents are usually based on other patents. In this environment, patent scope and infringement claims are strong problems which stand in front of patent offices and courts. Chang (1995) builds up a model which deals with patent scope and cumulative innovation. According to Chang, incentives to invent depend upon the patent scope and anti-trust policy. Furthermore, patent policy should be designed and implemented by considering cumulative nature of inventions. Chang indicates that, courts have a great responsibility in the implementation of both anti-trust and patent policies.

Chang's two-period model consists of two firms, and identical consumers with unit demand. In each period, only one firm makes a contribution to the state of the art technology and second period invention always depends on the first-period invention. The model assumes that courts have a perfect information about the value of each invention and make correct decisions on infringement claims. Naturally, these simplifying assumptions ignore the fact that many firms exist in reality and all of them are competing with each other in each period of time and perfect information about the value of patents is unrealistic.

Furthermore, patent systems have two major aspects, incentives to invent and encouragement for revelation of information within inventions. Incentives to invent and information revelation are both intensified by broader scope of patents. However, broader scope of patent also inhibits other firms to invest in further research. Therefore, patent offices and courts should be aware of these two contentious sides of patent protection system. In summary, Chang concludes that broad patent protection increases the dissemination of knowledge and the value of a patent should cover the return on the potential improvements to a certain extent.

2.4.2 Patent System and Market Structure

Conventional view indicates that patent system has two faces. Clearly, patent system fosters inventive activities by protecting intellectual property, while creating monopoly power which builds a barrier for potential entrants. Welfare impact of this tradeoff[53] draws attentions of both academicians and politicians. Bae (1993) investigates conventional belief of two contradictory faces of the patent protection. According to Bae, patent protection may shorten entry time as well as foster further inventive activities. In this sense, conventional view of tradeoff between stimulating innovation and monopoly power is a misconception.

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[53] This tradeoff can also be expressed as a balance between optimum utilization and optimum creation of knowledge.

The model compares two situations. In the first case, the innovator firm has only one option to deter entry namely to invest on an entry barrier. In the second situation, the firm has two options. It can deter entry either by investing or by using patent grant which impedes entry of others into the officially protected market. Obviously, the inventor firm is better-off in the second situation. The model implies that patent protection may shorten the entry-deterring period under the assumption that patent length is less than optimal duration of deterring entry. The reasoning is that with patent protection (the second case), the firm does not invest before the expiration of patent but a large amount of entry deterring investment is required between the dates of patent expiration and free entry. This large amount of investment requirement may affect the desicion of patent owner firm such that it may allow entry at the time patent expires. In short, under patent protection it would be better for the incumbent firm as it has two options, and it would also be better for the potential entrants since they may allowed to enter the market earlier.

In summary, Bae shows that patent system may shorten the entry deterrence period without disturbing the patent holder firm. In this sense, patent system fosters inventive activities without creating monopoly entry barriers. However, the model only focuses on free entry time, monopoly profit and free entry profit. It does not deal with welfare loss of consumers and dynamic nature of inventive activities. Moreover, according to Mansfield (1984), effective patent protection period is less than its expiration period. Therefore the main assumption of Bae, which implies that patent length is less than optimal free entry time, is empirically demolished.

Deviating from the optimistic literature, Chou and Shy (1993) show that patent system may create crowding-out effects and slow the process of product development. They construct an overlapping generation model which deals with saving, investment and product innovation. The study is based on a multiproduct general equilibrium model of product innovation. Two alternative patent regimes are investigated, namely one period-length and infinite length. Chou and Shy conclude that one period patent length is socially optimum.

According to Chou and Shy, the assumption that "long duration of patent increases the strength of the patent protection and fosters innovation" is not necessarily the case. In their overlapping generations model, long duration of patent protection creates long-lived monopoly firms, exhausts savings of young generations and therefore decreases new product development incentives of next generations. As an extreme case, infinitely lived monopolies crowd out the investment of the young generations' investments. More precisely, one period patent life system generates more innovation than infinite patent case. Then Chou and Shy indicate that one period patent length is optimum for all generations in three distinct model settings. The first model setting is love of variety approach of consumers. If consumers highly value product variety, one-period patents are optimum for all generations, since they generate more innovation. In contrast, infinite patent length regime is optimum if products are highly substitutable. The second model setting which gives the same outcome is high rates of time preferrences of consumers. Finally, the third model setting can be described as low population growth rate and low subtitutability of products. One-period patents are again socially optimum in the third case. Moreover, Chou and Shy report that high population growth rate results in an insignificant welfare difference between the two alternative patent regimes.

Chou and Shy emphasize that, patent system is one of the most perplexing objects in the industrial organization literature, since the patent system affects both product and R&D markets. The main aim is to encourage R&D markets but the system distorts product markets at the same time. Therefore, welfare impacts of patent system is a controversial subject. Finally, Chou and Shy denote that product development process creates externalities. More precisely, future generations benefit from previously invented products.

The weakness of the model is that it just compares two limiting patent length regimes; one period versus infinitely lived. Naturally, these two alternatives are insufficient to shape optimum patent policy. However, several patent lengths are difficult to solve by using the model, as the authors indicate.

2.4.3 Information Diffusion

Innovation is a sequencial process, further innovations generally lie on previously developed basic knowledge set. In this sense, innovations can be classified into two distinct sets, namely major innovations which create further applications, and secondary innovations which are applications of basic innovations. Major innovations are sources of secondary innovations and should be specially handled with in the patent system. Matutes, Regibeau and Rockett (1996) point out pioneer innovations and suggest the importance of patent scope in this framework. According to Matutes et al., patent system plays an important role in the diffusion of knowledge. Patent system should be designed to reduce the waiting period of the next innovation. They examine two alternative tools, patent length and scope, and conclude that patent scope is an efficient tool for speeding up inventive activities.

Matutes et al., indicate that information disclosure requirement of patent application is crucial for information diffusion. Innovative firms are willing to wait until they develop further applications before introducing a pioneer patent application, since rival firms acquire revealed information and develop commercially successful secondary applications. For a basic innovation, this means a high commercial risk. However, waiting period for patent applications has a welfare cost. Matutes et al. deal with this dynamic inefficiency and suggest an optimum patent policy. According to them, firm's incentive to reveal its pioneer inventive information can be kept alive by a wide patent scope. Furthermore, optimal scope and length of patent protection increases with the number of rival firms.

Finally, broader patent protection of the basic innovation fuels innovation diffusion through information disclosure. Authors also state that optimal patent policy involves both length and scope variables. In this sense, Gilbert and Shapiro's (1990) and Klemperer's (1990) results and their study are considered as complementary.

The value of patent protection, incentives for inventive activities and technical information diffusion among firms are all closely related with each other. Scotchmer and Green (1990) indicate that legal requirements of novelty and nonobviousness of patent application mainly determine the value of these concepts. They state that novelty and nonobviousness requirements are hard to define and apply. In fact, patent mechanism is a tripot which is constituted by standards, patent office and judicial system. However, there is still a gap for determination of optimal novelty and nonobviousness requirements.

Patent system roughly defines the novelty and nonobviousness requirements of new technology over previous patents. Innovative firms have to disclose the information of the new technology in order to get a patent grant. Disclosure of new technology creates externalities which indicate that the patent system has a dynamic nature. Moreover there are two alternative granting rules for patent applications, "first to file" which is applied in all countries except the United States and "first to invent" which is applied only in the United States. In the first case, filing is essential to get a grant, however in the second case, firms can prove their innovation later by presenting required documents.

In this environment, Scotchmer and Green model a dynamic system which represents novelty requirements and diffusion of innovation. They investigate two alternative requirements, namely strong and weak novelty, and examine the differences of "first to file" and "first to invent" policies. Strong novelty requirement creates more incentives to invest in inventive activities than weak novelty requirement. Since, minor improvements are considered as an infringement in the strong novelty requirement case, original patent receives higher profit hence incentive to do research is higher in this case. On the other hand, weak novelty requirement allows small contributions to get a patent award, therefore increases the number of patent applications and revelation of information. The public knowledge domain is enriched by weak novelty requirement which reduces the cost of sequential research of rival firms. These two contradictory effects determine the socially efficient stringency of novelty requirement. Scotchmer and Green indicate that alternative patenting rules play a major role in this framework. According to them, patent system has two main benefits, incentive to do research and information disclosure. Alternative economic policies may not achieve these two main benefits, at the same time.

Finally, Scotchmer and Green conclude that weak novelty requirement is the socially efficient way to drive both information sharing between firms and incentive to do research. The information revelation induces strong competition between firms and decreases the potential profit, however the innovative firm has an option to market the new technology without patenting. Nevertheless, the fact that "imitation and reverse engineering are easy in some sectors, therefore do not apply to the patent" cannot be an option for inventive firms. In this framework, "first to file" is a superior patenting rule.

2.4.4 Value of Patents

The determination of patent values is an ongoing empirical study which is still inconclusive, since patent counts are misleading indicators. Millions dollars of commercial value and valueless patents are all in the same pool.[54] However, determination of the precise patent value is critical, since it enables evaluation of the patent system and therefore international agreements. In the literature, there are two major alternative methods which address these problems. Clearly, patent citation and patent renewal methods are the most accepted ones. Lanjouw (1993) builds a patent renewal model in order to estimate private value of patent protection.

The model considers four technology fields, namely computers, textiles, pharmaceuticals and combustion engines. The data are collected from West Germany patent database and includes Japan, Europe and United States originated patents. Patent renewal models are based on the fact that an annual patent fee is required in order to keep patent in force and there is an increasing fee schedule. In this environment, it is logical to free commercially worthless patents to public domain. Furthermore, patent protection requires active participation of the owner, since patent system only defines rules and procedures but patent holder has to detect infringements by himself. If a patent holder is incapable or indifferent of defending his right, then others may infringe without any sanction. In this case, private value of the patent diminishes. Lanjouw deals with both renewal fee schedule and defending requirement and concludes that patent protection varies across technology fields. Moreover, patent renewal desicions are affected by infringement threat and litigation. Lanjouw reports that 65-95% of patents become free before maximum patent protection period is reached. This figure indicates that most patents are commercially worthless[55], and proves that patent counts are misleading indicators.

Lanjouw also suggests that the model can be used for the simulations of policy implications. For example, effects of patent length and renewal schedule on patent protection can be estimated. However, the model is limited to describe the whole

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54 The vast majority of patents are of little value, while only a small proportion of patents are extremely valuable.

55 Actually, this is not the only possibility. Obsolescence of patent causes withdrawing from renewal.

dimensions of the patent system, since patent scope and discrimination are issues of real life but are not incorporated in the model. Nevertheless, skewed distribution of patents and rapid obsolescence are observed by the model.

The number of patent applications are continuously increasing, but simple count of patents do not represent their technological significance. As mentioned before, patent citation is also an alternative for measuring real value of patents. The patent citation method depends on the cumulative nature of innovation process. As is well known, most of the inventions are only improvements of existing technology. Certainly, some inventions realize breakthrough in technology, however these are very rare. Therefore, patent data has a large variance, which implies the uncertainty of patent values. In this context, patent citations, which indicate references of prior patents, contain valuable information about the economic value of patents. Trajtenberg (1990) builds a patent citation model in order to evaluate simple patent counts. The model uses a narrow data set of Computed Tomography (CT) scanners patents and tests the significance of patent citation method. The data set only covers CT patents, since significance test requires independent measures of the innovations in this field. Trajtenberg considers innovation as a continuous and cumulative process, and concludes that weighted patent counts which depend on patent citations can be a good proxy for economic value of patents. Moreover, Trajtenberg indicates that, simple patent counts denote the level of R&D investments. That is to say, increasing numbers in patent applications indicate larger R&D efforts performed. However, larger R&D efforts do not represent higher social benefits.

Trajtenberg also states that, patent data is a rich source which covers all technology fields, and can be identified for different product classes. Moreover, it covers a long period of time, however it requires a refinement process before usage. Finally, the model should be tested further for different technology fields in the case of data availability of independent measures of patent value.

The majority of patents do not yield any private return, and probably do not have any social value. On the other hand, many technological contributions do not end up with a patent protection, since basic research activities and ideas are out of patent protection scope. Moreover, many firms do not apply for patent for secrecy purposes. Briefly, patenting is a strategic decision of firms. The main aim is to limit knowledge spillovers to rival firms. However, academic research activities are, generally, not subject to this reasoning. Moreover, as is well known, productivity of a firm depends on not only the rival firms' R&D efforts in the same industry but also R&D investments in other industries. In this sense patent data, which cover detailed information about inventor, location, industry classification etc., provide a tracable path for knowledge spillovers. Jaffe, Trajtenberg and Henderson (1992) build a model which investigates the geographic component of knowledge spillovers. Their starting point goes back to Alfred Marshall's three factors of geographic concentration, namely availability of specialized labor, intermediate inputs and possibility of knowledge spillovers among firms. The study uses university and corporate patent citation data of United States between 1975 and 1980 and reports the significant localization. The study also suggests that geographic localization of patent citations fade over time, and university and corporate originated patent citations show the same geographic localization characteristics. In addition, geographic localization is not limited within a product class, on the contrary it is widely distributed within all product classes.

In summary, Jaffe, Trajtenberg and Henderson investigate the invisible flow of knowledge among firms, universities and industries. Their findings suggest that there is geographic localization for knowledge diffusion. However, as they indicate, tracing information spillover is a difficult task, since there are other reasons for geographic localization which complicate the analysis. The Silicon Valley case is a famous example; there is a strong geographic localization of patent citations in Silicon Valley, but localized knowledge spillovers are perhaps the least effective of all the causes. Jaffe, Trajtenberg and Henderson indicate the pre-existing localization of related industries in Silicon Valley, and try to separate knowledge spillovers evidenced by patent citations from other causes. Finally, globalization efforts, strong competition in high-tech products, improvements in communication infrastructure and reducing communication costs may change the existing picture in the near future.

CHAPTER 3

TRADE RELATED INTELLECTUAL PROPERTY RIGHTS

Trade ministers from more than one hundred member countries of the GATT signed the Final Act embodying the Results of the Uruguay Round of Multilateral Trade Negotiations (MTNs), containing twentyeight agreements, in the ancient city of Marrakesh, On April 15, 1994. Among the agreements forming part of the Final Act of the Uruguay Round, the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) represents a significant development in the evolution of international intellectual property rights protection. The purpose of this chapter is to study the implications of the TRIPs Agreement. Section 3.1 provides a short overview of what intellectual property rights (IPRs) are. Importance of IPRs in international transactions is studied in section 3.2 and the main disciplines introduced by the TRIPs Agreement are dealt with in section 3.3. In section 3.4, the economic implications of the TRIPs Agreement are discussed.

3.1 Intellectual Property Rights

Intellectual property can be defined as information, which possesses commercial value. It is an asset, developed by inventive or creative work to which rights to exclude its unauthorized use and distribution have been granted by law. Protection[56] is given to ideas, technical solutions or other information that have been expressed in a legally admissible form. These expressions are, in some cases, subject to registration procedures. Intellectual property rights (IPRs) are exercised with respect to the products that carry the protected information and those who create the intangible may

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[56] Because products of knowledge are typically non-rival and non-excludable, a legal protection system is required in order to exploit its benefits by creator.

regulate the use of the creation and the commercialization[57] of the product that contains it.

Intellectual property legislation relates to the acquisition and use of a range of rights covering different types of creations. Namely an aesthetic character, technologies as well as information and signs of a purely commercial value are all considered as these types of creations. The main legal instruments utilized to protect different types of intellectual property rights are patents, utility models, industrial designs, trademarks, neighbouring rights, breeders' rights, geographical indications, copyrights, layout designs of integrated circuits and trade secrets. A short description of these rights are provided below under four headings, following the approach of Primo Braga, Fink and Sepulveda (1999): rights on industrial property, rights on literary and artistic property, sui-generis protection and trade secrets.

The types of instruments used in the case of industrial property are patents, utility models, industrial designs, trademarks and geographical indications. Patents are granted by legal authority[58] conferring the exclusive right to make, use, distribute or sell an invention in manufacturing (mainly in human necessities, transportation, chemical, metallurgy, pharmaceuticals, textiles, plastics, paper, engines, turbines, electronics, heating, weapons, industrial control and scientific equipment) for a fixed period of time such as twenty years[59]. In order to be patentable, an invention usually needs to meet the requirements of absolute novelty (previously unknown to the public), non-obviousness (containing sufficient inventive step over the state of the art technology) and industrial applicability (or usefulness). Patents may be granted for all types of products and processes in all fields of technology, including those related to the primary sector of production, namely metallurgy, construction, agriculture, fishing, textile or transportation, etc.

57 Commercialization of intellectual property is simply about planning how inventor will take his new idea to the marketplace.

58 National Patent Offices are legal authorities, which can issue patent grants.

59 Patent duration is counted from the filing date of patent application.

Patent-like protection is conferred for functional models and other minor innovations in mechanical industry under utility models[60]. Under utility models, protection is given to the functional aspect of models and designs, generally in the mechanical field. Although novelty and usefulness are required, the criteria of inventiveness for conferring protection are less strict than for patents. Actually the term of protection is shorter than the patent case. Utility models are distinct from industrial designs, which normally protect the ornamental or aesthetic aspect of an industrial article. Industrial designs in clothing, automobiles and electronics are characterized by their appeal to the eye. There is a wide variety of requirements and modalities of protection pertaining to industrial designs. In some countries, protection is based on novelty, while in others on originality. Further, in some countries specific protection for an industrial design coexists with or can be accumulated to copyright or trademark protection for the same design. The term of protection generally ranges between five to fifteen years across countries.

On the other hand, trademarks are signs or symbols (including logos and names) registered by a manufacturer or merchant to identify goods and services of the original producer. It is applicable in all industries. A valid trademark allows the owner to exclude imitations that are likely to mislead the public, from commerce. The main aim is to reflect the quality of product or services to the consumers. Trademark provides an exclusive ownership and distinctiveness to a firm over its products. Protection is usually granted for ten years, and is renewable[61] as long as the trademark continues to be used. In this sense, it is different from other types of intellectual properties.

Finally geographical indications are the signs or expressions used to indicate that, a product or service such as wines, spirits, cheese or other food products originate in a particular country, region or place. There are different types of geographical indications. They are called appellations of origin, if the characteristics of the products or services can be attributed exclusively or essentially to natural and human factors of the place in which the products or services originate.

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60 Utility model is also known as petty patents.

61 Article 18 of TRIPs agreement states: "the registration of a trademark shall be renewable indefinitely".

The second heading in the intellectual property concept is the rights on literary and artistic property. The types of instruments used in the case of literary and artistic property are copyrights and neighbouring rights. Copyright, unlike the patent protection, protects only the expression of an idea, not the idea itself. This means that, in principle, protection is only extended to the form in which an idea is expressed, but not to the concepts, methods and ideas that are expressed. Copyright protection is provided to the authors of original works of authorship, including literary, artistic and scientific works in printing, entertainment (audio, video, motion pictures), software, and broadcasting industry. Copyright has also been extended to protect computer software and databases in some countries. Protection generally lasts for the life of the author plus fifty years or for fifty years (or more) in the case of works belonging to corporate bodies.

On the other hand, protection of performers, producers of phonograms and broadcasting organizations are included in neighbouring rights. The owners of copyright can generally prevent the unauthorized reproduction, distribution, sale and adaptation of an original work. The term of protection is at least fifty years for performers and producers of phonograms, and twenty years for broadcasting organizations.

The third heading, namely *sui generis* protection is concerned with breeders' rights and integrated circuits. A breeders' rights title is awarded on plant varieties in agriculture and food industry if the breeder can both describe genetically the new variety and show that it is characterized by homogeneity and genetic stability. That is to say, a plant variety must be new, stable, homogeneous and distinguishable in order to be protected. Exclusive rights, as a minimum, include the sale and distribution of the propagating materials for around twenty years. Unlike patents, breeders' rights permit the use by other breeders of a protected variety as a basis for the development of a new variety (the breeders' exemption) and for the re-use by farmers of seeds obtained from their own harvests (the farmer's privilege).

On the other hand, the integrated circuits layout in microelectronics industry is protected in most industrialized countries. It is a *sui generis* form of protection introduced for the first time in the United States in 1984 that allows the owner of the design to prevent the unauthorized reproduction and distribution of such designs.

Here, reverse engineering is generally allowed and the duration of protection is typically ten years.

Finally, the last form of protection is trade secrets protection. Trade secrets refer to confidential business information, such as lists of clients or recipes. This kind of information can be an enterprise's most valuable asset. In fact, trade secrets are one of the most widely used instruments in intellectual property protection field. Civil and criminal actions are provided for in most legislation against the unauthorized disclosure or use of confidential information. Actually, American Law Institute's definition is one of the most widely cited definitions: "A trade secret may consist of any formula, pattern device or compilation of information which is used in one's business, and which gives him an opportunity to obtain an advantage over competitors who do not know or use it ... it differs from other secret information in a business ... in that, it is not simply information as to single or ephemeral events ... A trade secret is a process or device for continuous use in the operation of the business". The last part of this definition deserves special attention. In the trade secrets case, there is no exclusive right, but an indirect type of protection based on a factual characteristic of the information (its secret nature) and its business value. Trade secrets are protected as long as the information is kept secret.

IPRs are created by national laws, but legal instruments are just one of the pieces that form a national system of intellectual property protection. The other pieces are the institutions in charge of administering the system (patent offices and patent attorneys) and the mechanisms available for enforcing these rights. Since laws, institutions administering IPRs and enforcement of these rights may differ among countries, the need for harmonization among nations may arise, as their residents seek protection for their works outside of the home country. There are several attempts, which address this problem. These attempts have generated numerous international treaties on IPRs. The Paris Convention for the Protection of Industrial Property, signed in 1883, and the Berne Convention for the Protection of Literary and Artistic Works, signed in 1886. These treaties have been revised since then and many additional treaties covering IPRs have been negotiated. Currently, most of these conventions are administered by the World Intellectual Property Organization (WIPO), a United Nation's specialized agency established in Switzerland in 1967. Despite WIPO efforts, the level of harmonization across countries remained limited until the mid 1980s.

The patent protection provided by law is valid only within applied country's borders. Clearly, patent protection has a territorial characteristic, so the grant of a patent in a country does not prevent a party in another country from making, using, or selling the same invention in that country. If an inventor wants to obtain a foreign patent protection, then he or she must apply for that, in that foreign country. National differences in application requirements and procedures make this process difficult. Patent Cooperation Treaty (PCT) was established to overcome these application problems in 1970. The PCT was amended in 1979 and modified in 1984.

Patent Cooperation Treaty (PCT) provides a relatively simple vehicle for obtaining foreign patent protection through a single application[62]. By filing a single PCT application in the "Receiving Office", patent protection may be sought in the participating countries[63], which include among others United States, Canada and Mexico, most European nations, and Japan. Inventors have the option to file either a national or a PCT application first. If a national application is filed first, then the PCT application must be filed within one year of the filing date of the national application. In either case, inventors obtain the benefit of the first filing date as the "priority" date. This priority date attaches not only to the first filed application, but all other related applications if all of the subsequent filing date requirements are timely met. Thus, publication or commercial usage occurring after the priority date does not affect the patentability of the invention.

3.2 Importance of Intellectual Property Rights in International Transactions

The subject of intellectual property rights has gained increasing importance in international transactions. Basically, there are three means by which intellectual property can be traded. The first one is the most classical way of trade, namely international exchange of goods, but in this time, these goods embody a creative

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[62] Once such an application is filed, an applicant has time to decide in which of the countries to continue with the application, thereby streamlining procedures and reducing costs.

[63] As of July 15, 1999 PCT has 104 contracting states.

component. A second alternative is to undertake foreign direct investment[64] (FDI), which transfers parent firm's technology, to establish various production and service relations. Finally, firms may trade their intellectual property internationally, by directly licensing rights to use in return for negotiated royalty payments.

In the first two cases, it is difficult to decompose the roles and contributions of information, capital and labor. On the other hand, it is relatively straightforward to determine the value of intellectual property traded in the third case. In addition to these three cases, firms may register intellectual property in various countries without exploiting the intellectual property in that country. The aim is to reduce the potential geographic range of competition for the inventive firm. However, existence of compulsory licensing mechanism in some countries may limit this implementation.

In this context, Fink and Primo Braga (1999) point out that the share of knowledge intensive or high technology products in total world trade has doubled between 1980 and 1994 from 12 to 24 percent and as a result, the importance of IPRs for trade has gained considerable significance. Table 3.1 shows the exports of these products for a selected number of countries in 1996. As pointed out by Fink and Primo Braga (1999) most international trade in high technology goods takes place among the developed countries. The countries considered include United States, Japan, Germany, UK and France from among the industrial countries and Mexico, Korea, China, Turkey and Hungary from among the developing countries. The data clearly reveal that the intellectual property intensive export volume is one-fifth[65] of total export volume in 1996. The table classified the selected intellectual property intensive goods into the following categories: patent, trademark and copyright goods using four digit trade data. The total volume of intellectual property intensive trade in selected countries is more than $470 billion in 1996; more than 80 percent of it is performed by 5 developed countries. Actually one fourth of the total trade is performed by United States only. Developing countries, except South Korea, achieve the highest export volume in 'Articles of apparel & clothing accessories' industry classification. Concerning the export of the patent goods, the first two countries in export volume are

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[64] Joint ventures and subsidiaries are also considered as alternative forms of foreign direct investment.

[65] As mentioned previously, the sole role of IP cannot be derived from these numbers.

United States and Japan. In trademark goods, the first three countries in export volume are United States, China and France. In copyright goods, the first two countries in export volume are United States and Germany. Actually these figures explain the firm attitude of United States in the protection of intellectual property in the world scale.

The increasing importance of IPRs in international transactions is also manifested in the growth of trade in services and foreign direct investment (FDI). Services have been a dynamic component of world trade with the share of services in global trade increasing from 15 percent in 1980 to 18 percent in 1995. Among the services, IPRs are the most relevant for computer and information services, and loyalties and license fees. Studies reveal that, the largest recipient of royalties and license fees has been the United States. According to UNCTAD (1998), the US total receipts from patents, royalties and license fees has increased from $ 7.9 billion in 1986 to $ 30 billion in 1996.

On the other hand, the FDI stock has increased fourfold between 1982 and 1994. The FDI outflow amounted to $424 billion in 1997. In the same year, the value of international production, attributed to 53,000 multinational corporations and their 450,000 foreign affiliates was $9.5 trillion as measured by the estimated global sales of foreign affiliates. In 1996, top four countries[66] accounted for 56.2 percent of all FDI inflows of developing countries. For the United States, about 50 percent outflow in 1997 was in services (including wholesale trade, banking, finance, insurance and real estate) and 28.2 percent was in manufacturing. As some of the studies indicate, the quality and content of FDI are affected by the stringency of host countries' intellectual property regime.

[66] China, Brazil, Singapore and Mexico are the major FDI receiving countries in 1996.

Table 3.1.: Exports of IPRs Intensive Goods for Selected Number of Countries during 1996 (Million USD)

	Germany	Japan	USA	France	UK	China	Hungary	Korea	Mexico	Turkey	Total
Total Export Volume	**512.711**	**410.947**	**582.118**	**283.970**	**258.928**	**151.048**	**13.145**	**124.547**	**95.657**	**23.224**	**2.456.294**
Export Share of Total IP Intensive Goods	**14,4%**	**20,4%**	**19,7%**	**19,9%**	**19,2%**	**29,6%**	**16,8%**	**19,3%**	**16,3%**	**29,9%**	**19,2%**
Export Share of Patent Goods	6,8%	14,2%	11,0%	6,4%	9,2%	4,8%	1,5%	12,7%	5,5%	0,6%	9,3%
Export Share of Trade Mark Goods	6,4%	5,2%	6,8%	12,4%	7,9%	24,1%	14,8%	5,3%	9,9%	28,8%	8,6%
Export Share of Copyright Goods	1,3%	1,0%	1,9%	1,1%	2,1%	0,6%	0,5%	1,3%	0,8%	0,6%	1,4%
Patent Goods	**34.760**	**58.223**	**64.160**	**18.158**	**23.779**	**7.321**	**200**	**15.764**	**5.226**	**135**	**227.725**
512 Alcohols, phenols, halogenat., sulfonat., nitrat. der.	1.975	864	1.792	582	382	191	7	97	122	21	6.033
541 Medicinal and pharmaceutical products, excluding 542	3.986	1.170	4.466	1.920	1.447	1.204	53	208	322	37	14.815
583 Monofilaments, of plastics, cross-section > 1mm	583	13	100	96	78	4	6	4	1	5	891
728 Other machinery for particular industries, n.e.s.	10.542	10.729	9.687	2.384	2.237	417	67	1.307	291	43	37.703
737 Metalworking machinery (excludingmachine-tools) & parts	1.646	1.908	1.093	556	452	95	19	111	120	8	6.006
751 Office machines	1.218	3.440	1.010	722	1.107	1.118	7	236	387	5	9.250
752 Automatic data processing machines, n.e.s.	6.902	15.849	21.385	6.498	11.907	3.690	12	4.707	2.699	11	73.660
774 Electro-diagnostic appa. for medical sciences, etc.	2.692	1.779	3.527	790	437	51	18	77	78	3	9.452
7764 Electronic integrated circuits & microassemblies	5.102	22.283	20.709	4.494	5.534	540	10	9.017	1.196	2	68.885
87413 Surveying, hydrological, etc., instruments & applian.	114	188	391	115	196	12	1	1	11	1	1.030
Trade Mark Goods	**32.602**	**21.185**	**39.550**	**35.202**	**20.437**	**36.414**	**1.950**	**6.629**	**9.512**	**6.681**	**210.162**
112 Alcoholic beverages	1.622	129	1.068	7.330	4.207	107	163	81	572	53	15.332
553 Perfumery, cosmetics or toilet prepar. (excluding soaps)	2.002	347	2.179	5.879	2.272	136	26	60	92	36	13.030
665 Glassware	1.161	343	680	1.775	293	252	46	84	222	171	5.028
784 Parts & accessories of vehicles of 722, 781, 782, 783	14.286	17.446	23.832	10.349	6.324	383	256	1.037	2.975	213	77.101
821 Furniture & parts; bedding & similar stuffed furni.	4.408	364	3.323	2.112	1.480	1.887	277	204	1.345	87	15.488
831 Travel goods, handbags & similar containers	371	37	306	1.233	209	2.725	44	541	143	38	5.648
84 Articles of apparel & clothing accessories	7.340	498	7.285	5.530	4.894	25.034	1.110	4.221	3.749	6.076	65.737
885 Watches & clocks	724	1.879	277	672	413	1.964	4	262	37	2	6.233
8942 Children's toys	686	141	598	322	345	3.924	24	141	378	5	6.566
Copyright Goods	**6.454**	**4.282**	**10.900**	**3.063**	**5.425**	**917**	**63**	**1.634**	**812**	**138**	**33.688**
892 Printed matter	3.714	489	4.346	1.905	3.414	228	42	183	213	23	14.556
898 Musical instruments, parts; records, tapes & similar	2.740	3.793	6.555	1.158	2.011	689	21	1.451	599	115	19.132

At this point, it is necessary to note that there is no uniformity in IPRs across countries. Studies indicate that the stringency of IPRs systems vary significantly across countries. United States can be considered to have the strongest IPRs regime in the world. The IPRs regimes of other countries range from very low in some of the developing countries to high levels of protection prevailing in most developed countries. During the 1980s, industrialized countries started to pressure the developing countries, which had low levels of IPRs protection, to strengthen their IPRs regimes. Among the reasons for the change in policy of the industrialized countries, the following are emphasize:

- Policy makers increasingly recognize technology as a key factor affecting competitiveness, particularly in the production and trade of technology-intensive goods and services. It is noted that, R&D expenditures have shown a steady increase since the 1970s in industrialized countries. Private sector accounts for a growing share of total R&D expenditures and in many of these countries, more than half of the R&D expenditures is funded by the enterprises themselves. Studies reveal that the OECD countries account for 74 percent of world R&D expenditures. These R&D activities are the origin of most innovations, which appear in the market.

- US leadership in manufacturing and technology is challenged by the catching up of Japan and a few other countries, including the newly industrialized countries, which become aggressive competitors in consumer electronics, microelectronics, robotics, computers and peripherals, as well as in various services. These challenges are perceived in the United States as resulting from an open technological and scientific system, which allow other countries to imitate US innovations and which give rise to the proliferation of counterfeiting and piracy. Since R&D activities are very costly, there is a strong interest on the part of industrialized countries in a more robust and forceful IPRs system in order to help their enterprises recoup the costs of their R&D efforts and to strengthen their appropriation of the results of R&D.

- Finally, the application of new technologies has given rise to a number of new situations and problems, particularly in the field of information technologies and biotechnology. For example, large-scale software producers insist on the protection of computer programmes. The same attitude can also be observed both in the field of biotechnology and pharmaceuticals.

The data and results reported in the Table 3.2 reveal that, developed countries have stronger patent protection systems than developing countries. However, it is interesting to note that, less developed countries have generally higher protection standards than developing countries. This observation can be explained as they are mainly ex-colony countries, and their legislation systems are very similar to developed countries' systems. Sierra Leone, Sri Lanka, Uganda and Zaire have more patent protection strength than many developing countries as indicated in all of three studies, namely Rapp and Rozek (1990), Maskus and Penubarti (1995) and Gould and Gruben (1996).

Rapp and Rozek's index of patent protection is based on surveys of business and government officials and an examination of patent laws themselves. The index indicates the conformity of a country's patent laws to the minimum standards proposed in the Guidelines for Standards for the Protection and Enforcement of Patents of the United States Chamber of Commerce Intellectual Property Task Force (1987). Their index ranks the level of patent protection on a scale from 0 to 5, where 0 is assigned to a country with no patent protection at all and 5 is assigned to a country whose laws are fully consistent with minimum standards. The data of this study pertains to 1984.

The second index, namely Maskus and Penubarti's index is based on the index of Rapp and Rozek's, whereas it is corrected by an instrumental variables approach. Actually Maskus and Penubarti report that there are two potential sources of error in Rapp and Rozek's study. Firstly, as mentioned above, a number of poor countries, such as Ghana and Nigeria, have stringent patent laws at least theoretically, since they were British colonies and their regimes were similar to UK patent act.

Table 3.2. IPRs Protection Regimes in Different Countries

Country	PSI	PSII	PSIII	PSIV	P	B	PCT
Argentina	1	2,5	4,0	2	+	+	--
Australia	4	4,6	4,9	5	+	+	+
Austria	4	4,4	4,4	5	+	+	+
Bangladesh	2	2,1		3	+	+	--
Belgium	5	4,5	6,0	6	+	+	+
Benin	2	3,2		3	+	+	+
Bolivia	1	1,1		2	+	+	--
Brazil	1	2,1	3,9	2	+	+	+
Burkina Faso	2	3,1		3	+	+	+
Cameroon	2	3,0		3	+	+	+
Canada	4	5,0		5	+	+	+
Chile	2	1,8	4,2	3	+	+	--
Colombia	2	1,5	2,5	3	+	+	--
Costa Rica	3	2,9		4	+	+	+
Denmark	5	4,4	4,7	6	+	+	+
Dominic Rep.	2	3,2		4	+	+	+
Ecuador	1	2,4	3,8	2	+	+	--
Egypt	2	2,8		3	+	+	--
El Salvador	3	2,5		4	+	+	--
Finland	4	4,3		5	+	+	+
France	4	4,8	5,1	6	+	+	+
Germany	5	4,5	5,3	6	+	+	+
Ghana	4	2,5		5	+	+	+
Greece	4	2,6	4,9	5	+	+	+
Guatemala	3	2,4		4	+	+	--
Honduras	1	0,0		2	+	+	--
Hungary	3	2,9			+	+	+
India	1	2,3	3,6	2	+	+	+
Indonesia	0	1,7	0,0		+	+	+
Ireland	4	4,5	4,7	5	+	+	+
Israel	5	4,9		6	+	+	+
Italy	5	4,3	5,7	6	+	+	+
Jamaica	3	3,2		4	+	+	--
Japan	4	4,4	5,7	5	+	+	+
Jordan	4	3,0		5	+	+	--
Kenya	4	3,4		5	+	+	+
Korea	3	3,6	4,0	4	+	+	+
Liberia	4	2,1		5	+	+	+
Libya	2	0,0			+	+	--
Malawi	4	3,1		5	+	+	+
Malaysia	3	3,2	4,6	4	+	+	--
Mali	2	2,0		3	+	+	+
Mauritius	4	2,8		5	+	+	--
Mexico	2	2,3	2,3	3	+	+	+
Morocco	4	2,3		5	+	+	+
Netherlands	5	4,3	5,2	6	+	+	+
New Zealand	4	4,5		5	+	+	+
Nigeria	4	3,3		3	+	+	+
Norway	4	3,4		5	+	+	+
Oman	0	0,9			+	+	--
Pakistan	3	2,2		4	--	+	--
Panama	2	2,7		3	+	+	--
Paraguay	1	1,6		2	+	+	--
Peru	1	1,3	1,4	2	+	+	--
Philippines	4	3,1	5,3	5	+	+	--
Portugal	3	2,8	5,1	4	+	+	+
Sierra Leone	4	3,1		5	+	--	--
Singapore	4	3,7	5,7	5	+	+	+
South Africa	5	4,0		6	+	+	+
Spain	4	2,7	3,8	5	+	+	+
Sri Lanka	4	3,8		5	+	+	+
Sweden	5	4,8	5,8	6	+	+	+
Switzerland	5	4,9	4,8	6	+	+	+
Syria	2	2,0		3	--	--	--
Thailand	1	1,7	2,5	2	--	+	--
Togo	2	3,0		3	+	+	+
Tunisia	3	2,4		4	+	+	--
Turkey	1	1,9		2	+	+	+
Uganda	4	3,4		5	+	--	+
UK	5	5,2	5,7	6	+	+	+
Uruguay	3	2,5		4	+	+	--
USA	5	5,3		6	+	+	+
Venezuela	2	1,8	2,5	3	+	+	--
Yugoslavia	2	2,7			+	+	+
Zaire	4	1,9		5	+	+	--
Zambia	3	3,5		4	+	+	--
Zimbabwe	4	4,0		5	+	+	+

PS I: Patent Strength index of Rapp and Rozek (1990) (0-5) covers mid-1980

PS II: Patent Strength index of Maskus and Penubarti (1995) (0-5)

PS III: Modified Version of Patent Strength index of Kondo (1995) (0-6) covers 1979-1987

PS IV: Patent Strength index of Gould and Gruben (1996) (1-6)

P: Paris Convention Membership as of September 28, 1999

B: Berne Convention Membership as of September 28, 1999

PCT: Patent Cooperation Treaty Membership as of September 28, 1999

On the other hand, there is no effective enforcement in these countries. Secondly, there is a potential endogeneity problem due to mutual causality between level of economic development and effectiveness of legislation and enforcement. Maskus and Penubarti perform a correction estimation, considering the level of economic development (GDP per capita, primary exports as a share of total exports, infant mortality rate, and secondary enrollment ratios), a dummy variable corresponding to British and French colonies and memberships in intellectual property conventions.

The third index in Table 3.2 is the index of Kondo (1995). He builds an index, which covers thirty-three countries and fifteen years long period of time. This index is based on three main dimensions of patent laws. They are; patent life, exclusionary provisions, and scope provisions. In the first dimension, the patent duration is the only patent law provision. The exclusionary provisions dimension covers the specific technological fields[67], which are excluded from patent protection in some countries. The third dimension, namely scope provisions address the restrictions and extensions[68] on the patent grants. The scope provisions consist of fifteen important restrictions and extensions. The first dimension is measured easily for all sample countries. The second dimension is determined by a relatively easy methodology; number of technology fields is counted for each country. The third dimension is the most difficult to obtain. Kondo performs a mail survey to obtain the expert opinions on the relative importance of the fifteen scope provisions. Kondo then calculates the overall patent stringency index by using principal component analysis.

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67 These technological fields are electrical method claims, microbiological processes, microbiologically processed products, chemical products, pharmaceutical products, food products, and computer programs.

68 They can be listed as follows; cancellation for non-use, compulsory licensing due to non-use, compulsory licensing due to insufficient use, early publication of the patent application, first-to-file system, no loss of novelty if early disclosure of invention occurred in an official exhibition, no loss of novelty if early disclosure of invention occurred while carrying out research with scientific objectives, no loss of novelty if early disclosure of invention occurred while carrying out public experimentation, patent infringement being a crime, possible cancellation on public interest or national security grounds, protection of applicant against infringers before grant of patent, regulation restricting licensing, requirement of licensing-dependent patents, requirement of cross-licensing, validity non-judicially arbitrated.

Finally, Gould and Gruben's index is also based on the index of Rapp and Rozek. Gould and Gruben adjust the original index and change the scale of it. They also indicate the potential problem of overestimation, since the index is primarily based on the laws in force against infringement but not on their enforcement or implementation.

To sum up, there is only limited number of studies in the literature, which aim to construct a proxy for the strength of patent protection. These studies generally require judgment over the role of law, since laws on the books may be different than laws in practice. In these studies, only the patent law is investigated to determine the patent protection stringency. On the other hand, all forms of intellectual property laws should be included in order to determine the overall IP protection stringency. Namely copyright, patents, trade secrets, trademarks, chip topology and other forms of IP should be considered. In addition, efficiency and transparency of public administration should be investigated. Finally, enforcement mechanism should be searched. Obviously, full determination of IP stringency is a difficult and costly task to perform.

In addition to evaluation of IPRs in international transactions and patent strength, the exchange of patents between countries[69] is also an important indicator. Table 3.3 presents distribution of patent grants among selected 10 major patent source countries in 1996. Some important observations can be done using the data presented in Table 3.3:

- Table 3.3 reveals that United States is absolutely the major patent exporting country. Japan and Germany are following United States.
- The selected ten exporting countries cover almost 90% of all patent grants for all countries.

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69 Patent data contain valuable information about the density of information generation activities. However as stated in Chapter I, it should be refined before any evaluation, since nearly 80% of patent applications have no economic value. In any case, number of foreign patent grants indicate the interest of source country on host country.

- The ratio of foreign patent grants to total patent grants in a country is higher than 90% for Hong Kong, Indonesia, Mexico, Turkey and Venezuela. This indicates that domestic contribution is negligible in these five countries.

- F/T ratio (foreign to total number of patents) is less than 50% for only Japan and United States. Actually, Japanese case is strictly different than even United States' case. Foreign patent grants constitute only 13% of total patent grants in Japan. The rest of the countries have higher foreign contribution.

- The data also reveal that there is a geographic factor in patent grants. That is to say, United States' share is between 27% and 30% for France, Germany and United Kingdom, which show uniform distribution characteristic. On the other hand, United States' share is 48% for Argentina, 52% for Chile, 68% for both Mexico and Venezuela, and finally 52% for Canada. The reasoning behind geographic factor may be the effort of deterrence for parallel trade possibility. That is to say, United States may aim to prevent the import of copied products from its neighbours by obtaining patent protection in those countries. Importing from other regions may be more costly due to long distance.

- The most active patent exchange is between United States and Japan, Table 3.3 indicates that nearly half of the foreign patent grants in the United States are Japan originated. Equivalently, more than half of all the foreign patent grants in Japan are United States originated. However, Japanese economy is relatively closed to foreign patents, as mentioned above.

Table 3.3. Distribution of Patent Grants During 1996 (broken down according to the country of residence of the applicant) Source: WIPO, Geneva.

Host Countries		Major Patent Source Countries Percentage of Patent Grants - 1996												
		CA	CH	DE	FR	GB	IT	JP	NL	SE	US	Others	Total	F/T
AR	Argentina	1,3	5,8	**8,9**	**6,7**	4,2	5,5	2,6	3,7	0,6	**47,8**	12,8	100	0,80
BR	Brazil	0,8	5,0	**15,7**	7,4	4,2	4,3	8,2	**8,6**	2,3	**37,8**	5,7	100	0,87
CL	Chile	1,9	3,8	**8,1**	4,4	6,3	0,6	0,0	3,8	**7,5**	**51,9**	11,9	100	0,87
CN	China	1,3	3,8	**9,3**	7,2	4,1	2,9	**27,9**	3,7	1,2	**28,2**	10,4	100	0,54
EG	Egypt	0,5	3,9	8,3	**10,3**	**10,3**	3,4	3,4	1,0	2,9	**46,1**	9,8	100	0,82
HK	Hong Kong	0,6	4,7	**13,9**	2,2	11,1	0,6	**16,6**	8,1	1,0	**34,9**	6,2	100	**0,98**
ID	Indonesia	1,0	3,7	6,8	5,0	**8,9**	2,4	**26,5**	3,3	3,1	**26,3**	12,8	100	**0,97**
MX	Mexico	1,9	3,3	**7,0**	**3,5**	2,3	1,7	3,3	1,6	2,9	**67,9**	4,8	100	**0,96**
KR	Korea	0,3	1,8	**5,1**	2,7	1,9	1,0	**57,7**	2,6	0,8	**23,6**	2,6	100	0,50
TR	Turkey	0,7	5,1	**20,2**	**10,6**	7,9	2,7	3,4	4,5	0,5	**37,9**	6,3	100	0,92
VE	Venezuela	2,2	**3,8**	2,8	3,2	**4,2**	3,3	1,2	2,6	1,2	**68,4**	7,1	100	0,94
IN	India	1,4	3,0	**15,3**	6,4	**8,2**	1,4	6,1	2,7	0,5	**42,4**	12,9	100	0,65
CA	Canada		1,4	**6,0**	4,1	3,1	1,4	**24,1**	1,3	0,9	**52,2**	5,5	100	0,90
FR	France	0,8	3,9	**22,9**		5,1	3,7	**24,0**	3,0	1,7	**27,3**	7,5	100	0,76
DE	Germany	0,9	4,7		**9,1**	5,5	3,8	**32,8**	3,3	2,0	**29,7**	8,2	100	0,64
IT	Italy	0,9	4,5	**25,2**	10,0	5,4		**14,3**	3,0	1,9	**26,8**	7,9	100	0,78
JP	Japan	0,9	4,2	**17,4**	**6,1**	3,6	2,1		3,7	1,6	**51,4**	8,9	100	**0,13**
NL	Netherlands	1,0	4,4	**23,2**	8,9	6,2	3,7	**14,7**		2,2	**27,2**	8,6	100	0,93
SE	Sweden	1,2	4,5	**22,9**	9,5	6,7	4,5	**9,9**	3,3		**27,6**	9,8	100	0,91
CH	Switzerland	1,0		**27,5**	9,6	6,0	4,4	**9,8**	3,1	2,4	**25,0**	11,2	100	0,88
GB	UK	1,0	3,3	**20,0**	7,7		3,1	**25,5**	2,7	1,7	**27,4**	7,7	100	0,90
US	USA	4,6	2,3	**14,0**	5,7	5,1	2,5	**47,5**	1,6	1,8		14,9	100	**0,44**

F/T: Ratio of Foreign Grants of Patents to Total Grants of Patents

3.3 The TRIPs Agreement

3.3.1 Historical Developments of Multinational Trade Negotiations (MTNs)

Concept of globalization has gained growing importance recently. Especially after the end of the second world war, there is a trend towards economic and military integration. International integration and multilateral negotiations are supported by peace keeping efforts. United Nations is established during this period of time. Its main objectives are solving disputes by negotiating and increasing the level of world welfare. These two objectives are assumed to reduce the risk of the third world war.

In such an environment, first multilateral trade negotiations started with the contribution of 23 countries in 1947 in Geneva. Initially, barriers to trade were targeted. These trade negotiations were later called General Agreement on Trade and Tariff (GATT). Following multilateral trade negotiations, which again focused on reduction of tariff, were held in Annecy in 1949, in Torquay in 1951, in Geneva in 1956, 1960, and 1961. 13 countries in 1949, 38 countries in 1951, 26 countries in 1956, and 26 countries in 1960-1961 contributed to these trade negotiations. Naturally these multilateral trade negotiations have no solid legal foundation. In any case during the post war period, world trade has experienced an exceptional growth. Volume of the total trade in 1997 was 14-times the level of 1950. Increasing volume of the world trade indicates the success of these tariff reduction efforts.

In 1964, Kennedy Round of GATT launched in Geneva. Kennedy Round lasted for 3 years and it was the first time, anti-dumping measures were included in the agenda of negotiations. The next round, which is known as Tokyo Round, started in 1973 and lasted for 6 years. The agenda of Tokyo Round consisted of tariffs, non-tariff measures and framework agreements. Tokyo Round had a narrow focus on the issue of counterfeit good trading. The last and the broadest scoped round is Uruguay Round (UR) which started in Punta del Este in September 1986 and was signed by member countries' ministers in Marrakesh on 15 April 1994. This eight years long round dealt with tariffs, non-tariff measures, rules, services, intellectual property rights, dispute settlements, textiles, agriculture, and creation of the World Trade Organization.

The World Trade Organization (WTO) is the outcome of this last GATT round and came into being on January 1, 1995. WTO can be considered as an ultimate successor to the multilateral trade negotiations. WTO is a single institution, which encompasses the whole aspects of the GATT. Ministerial Conference of the WTO comes together at least once in every two years. WTO has 134 member countries as of 1999. Administering WTO trade agreements, forum for trade negotiations, handling trade disputes, monitoring national trade policies, technical assistance, and training for developing countries and cooperation with other international organizations are major functions of the WTO.

1994 GATT agreement introduces new arrangements such as abolition of non-tariff barriers, reductions in the subsidies and tariffs, the adoption of an anti-dumping code, and constitution of international rules concerning intellectual property rights and trade related investment measures, technical regulations and standards, custom classification, valuation and preshipment inspection and rules of origin.

The World Trade Organization rests on three main agreements, namely General Agreement on Tariffs and Trade (GATT), General Agreement on Trade in Services (GATS), Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs). Basically, GATT deals with trade in goods, GATS deals with trade in services, and TRIPs deals with such issues as copyright, trademarks, patents, industrial designs and trade secrets. The main objective is welfare gain and political stability through liberalization of the international trade. TRIPs is perhaps one of the most negotiated agreements in the international arena. Some parties even argue that IPRs are not trade-related, however opposite parties advocate TRIPs, since IP intensive trade has continuously increased in the last two decades and must be regulated under an international umbrella. Therefore, international harmonization of national IPRs policies is required. In any case, the trade aspects of IPRs is needed to create a fair multilateral trade system in the 21st century.

3.3.2 Importance of Multilateral Agreements in IPRs

Information, technology, and quality concepts are rising values of this century, and obviously will be in the next. As mentioned before, increasing amount of knowledge intensive goods trade takes place. Moreover, global communications networks are continuously improving and reducing cost of usage. Information processing systems, electronic economy, and the internet face an enormous demand. A huge amount of information can be easily reached with almost zero cost through the internet from all around the world. All of these increase the dissemination of knowledge. In addition, digitization of knowledge, existence of low cost duplication and distribution increase the risk of piracy. One important subject needs to be mentioned here, namely changing characteristics of today's technologies. The rise of new technologies create a number of new situations and problems, especially in the biotechnology, microelectronics, and information technologies. Today's commodities are different from old ones. Therefore, international rules, standarts and enforcements must evolve to handle these changes in the 21st century. Information technologies, microelectronics and biotechnology are all new branches of the modern industries.

They can be easily copied so they need strong IPRs protection to recover initial R&D investments. Clearly global economy becomes more sensitive to losses from piracy and infringement.

Electronic economy covers production, advertising, sales and distribution of products via electronic networks. The rise of electronic economy requires new ways to protect IPRs. Significantly, this issue cannot be regulated without global cooperation such as TRIPs. WTO member countries and TRIPs Council have begun to explore how electronic economy should be regulated.

Global competition requires high research and development investments both in firm scale and national scale. Improving design and production techniques and shortening product life cycles make reverse engineering and consequently imitation of new products easier. This indicates that recouping[70] of research and development investment is getting difficult without world wide intellectual property protection. Moreover, acting with some encouragement from other industrially advanced countries, the United States generated a pressure over the countries[71] which were infringing developed countries' intellectual property during the 1980s. The pressures generated by the United States and increasing importance of intellectual property intensive trade put uniform and strong intellectual property protection on the agenda of both developing and developed countries. These policies' major aim was to stimulate technological development and enhance economic welfare. According to developed countries, this kind of interventions are required to achieve optimum allocation of resources in invention and innovation. However, economics of intellectual property rights are not concluded yet. This inconclusiveness depends on a question, namely how responsive is the supply of inventions to the stringency of intellectual property protection. There is no empirical answer to this question.

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70 Although counterfeit good trade had taken place for a long time, as technologies for copying became more advanced and the reproduction of IP easier and cheaper, trade in goods embodying stolen IP became an increasingly important issue for inventive countries.

71 Maskus (1997a) indicates that Canada, New Zealand, Portugal, Argentina, Brazil, Colombia, Indonesia, Republic of Korea, Malaysia, Mexico, Thailand, Bangladesh, Benin, Burkina Faso, Chile, Ecuador, Paraguay, Hungary, Mali, Egypt and China adopted stronger patent legislations after 1985. However, the reason of these policy shifts cannot be directly associated to the pressure of United States and European Union.

In this environment, TRIPs agreement determines the minimum and non-discriminatory standards for protecting various forms of intellectual property in the global scale. Until the UR, World Intellectual Property Organization (WIPO), a United Nations specialized agency, was the main international organization for IPRs protection. In fact WIPO is estalished on several international conventions and treaties. The major conventions and treaties are Paris convention (1883) for the protection of intellectual property, Bern convention (1971) for the protection of literary and artistic works, Rome convention (1961) for the protection of performers, producers of phonograms and broadcasting organizations and Washington treaty (1989) on intellectual property in respect of integrated circuits. However these conventions and treaties could not enforce signatory countries' governments to adopt higher protection for IPRs. In this context, WTO and WIPO made an agreement to cooperate in the implementation of the TRIPs agreement in 1995. This agreement, which entered into force in 1996, consists of three main areas, namely technical cooperation between Council of TRIPs and WIPO, implementation of protection procedures, and accessibility and translation of national regulations and laws.

Developing and developed countries have strictly different viewpoints in IPRs protection. Strong negotiations between developing and developed countries during UR justify this idea. Developing countries' point is that, stronger IP protection creates internationally unbeatable monopolies, therefore stronger IPRs protection is not optimum. However, developed countries state that, higher protection standards are welfare enhancing due to dynamic nature of IP production and lead to increments in knowledge dissemination. At this point, differences among developed countries should also be mentioned. United States, that has a strong comparative advantage, is the strongest advocate of the developed block. United States has high technology which is very sensitive to IPRs protection, namely broadcasting, entertainment, software, information systems, genetics, biotechnology, and pharmacology. However, other developed countries are reluctant as compared to United States. United States insists that all aspects of IPRs should be covered rather than counterfeit good trade only. On the opposite side, developing countries have no consensus among themselves either. Least developed countries, generally colony countries, had stronger IPRs protection relative to developing countries before multilateral trade negotiations.

In fact, least developed[72] and industrialized countries have stronger intellectual property protection than developing countries that have medium income level.

Developing countries were generally passive observers until the UR of multilateral trade negotiations. TRIPs agreement was the scene of the active participation of developing countries. Developing countries prepared several alternative proposals. Initially, developing countries argued that TRIPs was not a GATT related issue. Specifically Argentina, Brasil, Chile, China, Colombia, Cuba, Egypt, Nigeria, Peru, Tanzania, and Uruguay submitted a proposal which suggested a dual-track approach. According to these 10 developing countries, counterfeit good trade could be covered within GATT structure, but enforcement of IPRs should be implemented outside of this system.

Finally, strong negotiations ended up with an agreement in 1994. The final text of agreement includes a transition period for the least developed and developing countries. TRIPs agreement was activated in January 1995 for developed countries. Developing and former centrally planned countries have 5 years, and least developing countries[73] have 11 years to implement the TRIPs agreement. On the other hand, the non-discrimination principle of the agreement was in force for all member countries from the beginning. All WTO member countries agreed to modify their national laws to conform to TRIPs standards. However, several developing countries will not be able to regulate their national policies in time due to scarcity of resources. Therefore, WTO prepares some support programmes for the least developed and developing countries. TRIPs agreement specifies minimum standards and is a binding enforcement mechanism but member countries are free to determine how to implement. Naturally, freedom in national implementation policy can be considered as a gap according to developed block. However, TRIPs is the most extensive agreement on IPRs protection ever concluded. In addition, the TRIPs agreement is to be reviewed periodically in order to deal with further developments in technology and in the world trade.

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72 The least developed countries' intellectual property protection is well established at least in law books.

73 Least developed countries may request a further extension.

3.3.3 Inclusion of IPRs in MTNs: The Overview of TRIPs Agreement

During the 1980s pressures from industrial countries gained momentum in the world economy for strengthened IPRs protection. As international disputes over IPRs became common, a marriage between trade law and IPRs law started to emerge. To reduce piracy abroad, developed nations started to use trade measures and at the multilateral level, they pushed for the inclusion of trade related IPRs issues in the Uruguay Round of trade negotiations. The introduction of IPRs as one of the new issues in the Uruguay Round was approved at the Ministerial meeting held in Punta del Este in 1986, but it was limited only to the issue of trade in counterfeit goods. The industrialized countries' proposals concerning matters for negotiation were later extended to other aspects of IPRs. Until 1989, developing countries refused to enter into detailed negotiations, but the threat of unilateral retaliatory trade sanctions by the developed countries played a role in changing the stand of many developing countries on the matter. Finally, the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs) was signed by the vast majority of the contracting parties in Marrakesh in April 1994 together with the General Agreement on Trade in Services (GATS) and the GATT-1994.

The TRIPs Agreement is the most comprehensive multilateral agreement on intellectual property rights until now. The areas of intellectual property that it covers are: copyright and related rights, trademarks, geographical indications, industrial designs, patents, the layout designs of integrated circuits, and trade secrets. The Agreement[74] sets minimum standards of protection to be provided by each member by requiring that the substantive obligations of the main conventions of the World Intellectual Property Organization (WIPO), the Paris Convention for the Protection of Industrial Property and the Berne Convention for the Protection of Literary and Artistic Works in their most recent versions, must be complied with. With the exception of the provisions of the Berne Convention on moral rights, all the main substantive provisions of these conventions[75] are incorporated by reference and thus

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[74] Articles 2.1 and 9.1 of the TRIPs Agreement define the protection standards.

[75] These conventions did not achieve harmonization and go much beyond an agreement to apply the national treatment principle.

have become obligations under the TRIPs Agreement between WTO Member countries. In this sense, the TRIPs agreement covers all sides of intellectual property concept. On the other hand, TRIPs agreement has also an enforcement mechanism unlike these conventions.

Article 7 defines the objectives of the TRIPs agreement. It states that: "the protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to balance of rights and obligations".

The TRIPs Agreement[76] follows the GATT tradition in adopting the multilateral disciplines of non-discrimination and transparency commitment. Article 3.1 of the Agreement, namely national treatment, establishes that each member shall accord to the nationals of other members treatment no less favorable than that it accords to its own nationals with respect to the protection of intellectual property. Article 4 brings the concept of Most Favored Nation (MFN) treatment to the realm of international agreements on IPRs. The article establishes that any advantage, favor, privilege or immunity granted by a member to the nationals of any other country shall be accorded immediately and unconditionally to the nationals of all other members. The national treatment and the MFN principles are meant to end discrimination, both between foreigners and nationals and between nationals of different countries, which arises when IPRs are granted only to the nationals of the country that pressed for them. Article 63 on the other hand, introduces the principle of transparency. According to this article, members are required to publish laws, regulations, administrative and judicial procedures.

The TRIPs agreement was also motivated by a desire to improve on the existing situation characterized by widely varying standards in the protection and enforcement of intellectual property rights, and the lack of a multilateral framework of principles, rules and disciplines dealing with international trade in counterfeit goods. With the

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[76] The TRIPs Agreement has been analyzed by various economists. See e.g. Primo Braga (1995), Maskus (1997a) and Hoekman and Kostecki (1995).

ongoing integration of the world economy, and production and trade becoming more knowledge intensive, there was a concern that the inharmonious or absence of a multilateral framework for addressing intellectual property issues could create conflicts, including tensions in international trade. On the other hand, the TRIPs agreement is required to be improved to solve these problems, since it only defines the minimum standards. In accordance with Article 1, countries are free to determine the appropriate method for implementing the Agreement within their own legal system and practice. It states that: "Members may, but shall not be obliged to, implement in their law more extensive protection than is required by this agreement, provided that such protection does not contravene the provisions of this Agreement". Article 8 of the Agreement states: "Members may, in formulating or amending their laws and regulations, adopt measures necessary to protect public health and nutrition, and to promote the public interest in sectors of vital importance to their socio-economic and technological development, provided that such measures are consistent with the provisions of this Agreement. Appropriate measures, provided that they are consistent with the provisions of this Agreement, may be needed to prevent the abuse of intellectual property rights by right holders or the resort to practices which unreasonably restrain trade or adversely affect the international transfer of technology." These provisions facilitate legislating limitations to exclusive rights, as well as the enactment of legislative provisions concerning the compulsory licensing of certain IPRs.

Article 40 states the control of anti-competitive practices in contractual licenses. It denotes that some licensing practices or conditions pertaining to intellectual property rights may have adverse effects on trade and may impede the transfer and dissemination of knowledge by restraining competition. In these cases this article allows member countries to control and ban restrictive practices. The Agreement thus introduces the competition test for the purpose of verifying and stopping the use of restrictive clauses.

The Agreement also contains detailed provisions regarding judicial and administrative procedures and other measures related to the enforcement of rights. The provisions on enforcement contained in Part III of the Agreement aim to ensure that effective means of enforcement are available to right holders, and that enforcement procedures are applied in such a manner as to avoid the creation of barriers to legitimate trade and to provide for safeguards against their abuse. Non-compliance with the rules of the TRIPs Agreement gives rise to a dispute settlement procedure under the general WTO rules and to retaliatory commercial measures in any field by the country whose nationals are affected by such non-compliance. Since, within the WTO, adherence to the new IPRs universal standards will be monitored by the Council for TRIPs, the possibility of deviations from those standards is drastically reduced, unless a non-complying country is prepared to bear the costs of any trade restrictions that may be imposed. Article 64 defines the dispute settlement mechanism. Actually, it states that the provisions of Articles 22 and 23 of GATT 1994, which elaborate and build the Dispute Settlement Understanding, shall be applied in the case of conflicts between member countries.

The Agreement contains provisions, namely Article 65, that allow developing countries to delay complying with any or all of the Agreement's obligations for up to five years from the date of entry into force of the Agreement. An additional five years is allowed in the case of countries which did not grant product patents before entry into force of the Agreement but which now has to do so under the terms of the Agreement. Article 66 indicates that the least-developed countries may delay implementation for up to 11 years. This term may be extended by the Council for TRIPs upon request setting out the reasons. Article 66 also indicates that, developed country members should provide incentives to enterprises and institutions in their territories for the purpose of promoting and encouraging technology transfer to these least developed countries. The major aim is to support local technological base.

Finally, Article 71 of the Agreement defines the review and amendment conditions of TRIPs agreement. It states that the Agreement is to be reviewed for the first time five years from the date of its entry into force, and at two-yearly intervals thereafter. The Council for TRIPs may also undertake reviews when new developments warrant modifications.

The above considerations reveal that the TRIPs Agreement establishes minimum standards concerning the availability, scope, use and enforcement of IPRs. The Agreement does not cover utility models and breeders' rights. The absence of these two categories from the Agreement is explained by the relative lack of interest on the part of the major industrialized countries in these categories. Thus countries, in formulating and implementing national laws on utility models and breeders' rights, are not bound by any provisions of the TRIPs Agreement. In the following part, we concentrate on issues related to patents and industrial designs only and abstract from consideration of the other categories of IPRs.

3.3.4 Patents

Until 1995, countries were free to determine areas of non-patentability, the duration of the terms of patents and the set of exclusive rights conferred on patent holders. According to developed countries, this freedom, which was used by developing countries to frame their patent laws in accordance with their own objectives and interests, caused substantial frictions among the countries. In particular, industrial countries complained that in certain developing countries, the coverage of patents was very limited, that protection was provided for relatively short periods of time, that scope for compulsory licensing was broad and that there was ineffective enforcement. Developed countries argue that, they invest in research and development activities, whereas developing countries free ride. The TRIPs Agreement addressed all of these issues. Section 5 defines patentable subject matter, exclusive rights conferred, patent application conditions, exceptions, other use without authorization of the right holder, revocation, terms of protection, and patents in processes in detail.

Article 27 of the TRIPs Agreement states that patents shall be available for any inventions, whether products or processes, in all fields of technology subject to the requirements of novelty, inventiveness and industrial applicability. Exclusions from patentability, to protect public order or morality, to avoid serious prejudice to the environment, as well as to protect human, animal and plant life, are allowed. These exceptions are constrained by the requirement that the non-patentable invention be barred from commercial exploitation in the member country. According to Article 27.3, members may also exclude the following processes from patentability: (a) diagnostic, therapeutic and surgical methods for the treatment of humans or animals; (b) plants and animals other than microorganisms, and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes. Thus, countries are required to provide protection for biotechnological inventions but may exclude traditional breeding methods and higher life organisms from patentability. The second sentence of Article 27.3.b states that members should provide protection for plant varieties either by patents or by an effective *sui generis* system or by any combination thereof. As a result of this requirement, countries, which do not protect plant varieties have some room to develop their own systems of *sui generis* protection.

Article 28 of the TRIPs Agreement sets out the rights that a patent should confer on its title-holder, referring to the two traditional categories: product and process inventions. Patents relating to products confer the right to prevent third parties, which do not have the patentee's consent from making, using, offering for sale or importing that product for those purposes. On the other hand, patents relating to processes confer the right to prevent third parties from using the process and from using, offering for sale, selling, or importing the product obtained directly by that process. Patent owners shall also have the right to assign, or transfer by succession, the patent and to conclude licensing contracts. Although the Agreement mentions the right of importation, it does not stipulate the conditions of exhaustion of IPRs at international level. Article 6 of the TRIPs Agreement allows member countries to provide for the international exhaustion of rights and to admit parallel imports if they wish so.

With respect to the terms of protection of patents, we can note that Article 33 of the TRIPs Agreement requires the terms of protection available not to end before the expiration of a period of twenty years counted from the filing date.

The Agreement's provisions concerning compulsory licenses are presented in Article 31. This article contains a detailed set of conditions and limitations with respect to the granting of such licenses. Article 31 allows countries to determine the grounds for granting compulsory licenses in their national legislation. Although it refers to some specific grounds[77], it does not limit the purpose for which a compulsory license can be granted. The only exception with regard to the granting of compulsory licenses relates to "semiconductor technology", which can only be subject to compulsory licenses for public non-commercial use and to remedy anti-competitive practices. The granting of

[77] Specifically, national emergency, anti-competitive practices, public non-commercial use, dependent patents cases are subject to compulsory licensing.

compulsory licenses may be considered on various grounds. Article 8 of the TRIPs Agreement states, as mentioned above, the right of parties to adopt measures necessary to protect public health and nutrition, and to promote public interest in sectors of vital importance to their socio-economic and technological development, provided that such measures are consistent with the provisions of this Agreement. Based on this provision, and subject to the conditions specified in Article 31, compulsory licenses could be granted, for instance, for reasons of "public interest", or to satisfy public health objectives. Nevertheless, Article 27.1 of the TRIPs Agreement tends to limit this obligation, stating that, “patents shall be available and patent rights enjoyable without discrimination as to the place of invention, the field of technology and whether products are imported or locally produced”. Thus, the requirements of the provision will be met if the compulsory licensing rules do not treat imported and locally produced products differently. Thus, compulsory licenses can be granted in order to facilitate the import or the local production of a patented product.

A very detailed provision concerning compulsory licenses based on the dependency of patents is contained in Article 31.l. It sets out a number of conditions to be fulfilled for the granting of a compulsory license, relating to the technical and economic importance of the "second patent", the granting of "a cross license on reasonable terms" to the owner of the "first patent", and the non-assignability of the license. Compulsory licenses can also be conferred under Article 31 of the TRIPs Agreement in cases where the patent-holder refuses a third party's request for a voluntary license, whenever such a request is made based on reasonable commercial terms. As mentioned above, the Agreement does not limit the grounds on which a compulsory license may be granted and applied, with the exception of the case of semiconductor technology. Furthermore, although it is not possible to designate that all patents in a certain field of technology, such as pharmaceuticals, shall be subject to compulsory licensing, Article 27.1 does not prohibit compulsory license systems defined on the basis of a specific objective (e.g. to protect public health or the environment), the achievement of which would normally require the use of inventions belonging to different technological fields (e.g. chemistry, biotechnology, mechanical engineering, X-ray technology, etc.). Article 31.h stipulates that in the case of compulsory licensing, the title holder shall be paid "adequate remuneration in the circumstances of each case, taking into account the economic value of the authorization[78]". This provision would apply, in principle, to any kind of compulsory license.

South Centre (1997) emphasizes that the word 'adequate' does not give precise guidance to national judicial and administrative authorities. Considerable latitude is left for interpretation at the national level regarding the criteria to be used in determining what level of remuneration is to be deemed adequate. The same provision provides two elements affecting the interpretation: circumstances of each case and the economic value of the authorization. Thus, the economic environment of the licensee and of the country where it operates, as well as the purpose of the license, should be taken into consideration when establishing the remuneration due. A license conferred in order to satisfy public health or other social needs may be subject to parameters different from those applicable when purely commercial and industrial interests are involved. The economic value will differ depending on the size of the market to be supplied, the age of the technology, the rate of obsolescence in the respective sector, the degree of competition from substitute products and the coverage of the patent. These all indicate that compulsory licensing and adequate compensation are difficult to determine in any case.

3.3.5 Industrial Designs

Industrial designs are generally defined as features of ornamentation applied to an article. They consist of the shape, configuration, pattern or ornament or a combination thereof that give a product eye-appeal. Industrial designs are normally distinguished from designs, which are determined by their functional usefulness. The protection of industrial designs is probably one of the areas of intellectual property rights, with the greatest diversity in terms of the forms and extent of available protection. The matter of protection of industrial designs is dealt with, in two articles of the TRIPs Agreement.

In accordance with Article 25.1 of the Agreement, members are obliged to protect industrial designs that are new or original. The minimum standard specified in the

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[78] Article 31.i indicates that, the legal validity of any decision relating to the authorization of such use shall be subject to judicial review.

first part of Article 25.1 may be subject to other conditions. In addition to the condition that a design must be "new" or "original" to qualify for protection, members may require that designs differ significantly from known designs or combinations of known designs, that is, that they also possess a "distinctive character". On the other hand, members may exclude from protection designs, which are dictated essentially by technical or functional factors.

Article 26.1 requires Members to grant the owner of a protected industrial design, the right to prevent third parties that do not have the owner's consent from making, selling or importing articles bearing or embodying a design which is a copy, or substantially a copy, or the protected design, when such acts are undertaken for commercial purposes. On the other hand, Article 26.2 allows Members to provide limited exceptions to the protection of industrial designs, provided that such exceptions do not unreasonably conflict with the normal exploitation of protected industrial designs, and do not unreasonably prejudice the legitimate interest of the owner of the protected design, taking into account the legitimate interests of third parties. Finally Article 26.3 states that, the duration of protection shall amount to at least 10 years.

3.4 Economic Implications of the TRIPs Agreement

Some of the MTN parties, especially developing countries' representatives, oppose the inclusion of intellectual property protection under the WTO umbrella. According to them, multilateral trade agreements should only be limited to cover counterfeit good trade, but not national intellectual property protection policies. Some economists[79] indicate that intellectual property protection is not trade related, such as labor standards and environmental standards. They argue that, inclusion of such disciplines into trade negotiations may demolish the entire success of WTO, and trade negotiations, especially WTO should focus on trade liberalization. Panagariya (1999) dealt with this subject and has shown that world wide strong intellectual property protection shall disturb developing countries, moreover the overall effect may be welfare reducing. In this section, North - South patent models and effects of IPRs

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[79] See Jagdish Bhagwati and Martin Khor's presentations at the conference at Colombia University on Examining the Agenda for the Seattle Round, July 22-23, 1999.

protection on FDI are briefly surveyed in order to discuss the controversies about IPRs protection.

3.4.1 North – South Patent Models

In today's world, there is a strong conflict between developing and developed countries about the intellectual property protection. In fact, the last round of multilateral trade negotiations, Uruguay Round, witness solid disagreement between these two blocks of countries on TRIPs agreement. The TRIPs agreement involve, perhaps more than any of the other agreements, substantial changes in national legislation. These changes are designed to strengthen the protection of IPRs and have a positive impact on local innovation, foreign direct investment and technology transfer. On the other hand, a number of negative impacts, at least as far as less developed and developing countries are concerned, are also expected. Clearly, higher prices for technologies under patent protection and decrease in technology diffusion through reverse enginnering are predicted. Local innovative activities in developing countries are expected to be fostered to some degree, however, these countries have comparative disadvantage in innovation with respect to developed countries. In this context, developing countries argue that strong protection rules decrease world welfare due to increasing monopoly power of few multinational innovative firms. Deardorff (1992) shows that developing countries' argument may be proved under specified circumstances.

Deardorff builds a static model of invention and patent protection in order to examine the welfare effects of global protection. The model is based on four main assumptions. First, inventions take place in a single country, and the other country only makes consumptions of existing products. This assumption is widely accepted, and generally used in the North-South modeling technique. Second, there are identical demands for invented products across countries. However, the major results of the model may change by releasing this assumption. As Diwan and Rodrik (1991) indicate, if some inventions would be demanded more in the south than in the north, then extending patent protection may create welfare gain even for the south. Deardorff is also aware of this possibility. The third assumption is the linearity of the surplus function. The curvature and position of surplus function affect the result of the model. On the other hand, actual shape of surplus function is a subject of empirical studies rather than theoretical. The assumption of linearity is acceptable in the absence of such studies. Finally, the fourth assumption is about the diffusion of information. Deardorff assumes that innovation diffuses between countries without any cost and delay. In fact, this is the case in some industries, but it may not be generalized to the whole economy.

In the context of this model, Deardorff suggests that globally extended patent protection may be harmful for the world welfare as a whole. Definitely, innovative countries' welfare increases due to global patent protection, but welfare loss of other countries may outweigh this gain, since benefits of extending patent protection fall short with respect to costs of monopoly pricing of existing inventions at some point. Naturally, this result is an important policy implication which should be considered in the multilateral trade negotiations. According to Deardorff, at least the poorest countries should be left outside patent protection. Alternatively, sufficient transitional arrangements should be constituted for these least developed countries. During this period, developed countries and international organizations should support developing and less developed countries to build an effective national patent law and to create their own technological base. In fact, TRIPs agreement which is one of the major outcomes of Uruguay Round, constitutes transitional arrangement for least developed countries. The least developed countries are allowed 11 years to regulate their national laws and have options to lengthen this period.

Finally, Deardorff points out the similar reasoning behind limited period patent protection and limited geographic protection. According to him, both limitations are aimed to reduce the adverse monopoly effects of patent system. Nevertheless, the model simplifies the dynamic nature of the patent system and ignores its externalities.

The weak patent protection in developing countries, which is supposed to be supported by free-riding incentives, allows imitations of inventions of developed countries. Several developing countries have limited sectoral coverage, insignificant infringement fees, absence of specialized courts, discrimination in domestic applications, and administrative difficulties in their patent regimes before the TRIPs agreement. In addition, most of the inventive activities take place in the developed countries and are financed by their domestic markets. The cost of copyright and patent infringements in the United Stated is estimated as $15-60 billion by U.S. International

Trade Commision. According to the developed countries, free-riding incentives cause an underestimation of social value of innovations and there is a requirement of a cooperation which constitutes a socially efficient global intellectual property protection. The difference between private and social value of innovation causes undersupply in research and development activities. In this sense, TRIPs agreement is a great achievement for developed countries and a valuable milestone in the way of higher standards of intellectual property protection. In this framework, Diwan and Rodrik (1991) indicate that, developing countries may have incentives to provide an adequate patent protection to innovating firms in developed countries under a specific model assumption.

Diwan and Rodrik build a simple static model in the North-South context and examine the effects of patent protection. The model considers continuum of potential technologies, allows free entry into research and development sector, segments the northern and southern markets with respect to patent policy, examines the effects of strength of patent protection. According to Diwan and Rodrik, different technological needs and tastes may exist in the North and the South. In this sense, most of the literature deal with the quantity of innovations. However, scarcity of inventive resources and differences in the demands of northern and southern consumers, increase the importance of quality of innovations rather than quantity. All these indicate that the South may have incentives to protect patent rigths even in the absence of domestic innovations.

Diwan and Rodrik conclude that, increments in the strength of the southern patent protection cause increments in innovative activities for their preferred technologies, which means a reduction in innovations of other technologies preferred by the northern consumers. If technological differences between the North and the South diminish, then optimal patent protection both in the North and the South decrease. Finally, increase in the southern market size leads to the same result with the diminishing tehnological gap case. The model may not be applicable in all sectors, since technological needs and tastes are very close in some sectors, namely defence, telecommunications, information technology. In summary, differences in technological needs and tastes and scarcity of research resources may induce a race of patent protection between the North and the South. However, increasing globalization is expected to reduce national differences across countries except geographical ones.

On the other hand, innovative activities have a dynamic nature. New technologies build on previously taken steps. Dynamic nature of innovation constitutes the main argument of developed countries in the multilateral trade negotiations. In this environment, Helpman (1993) builds a dynamic general equilibrium, a free research market entry model which is based on the North – South framework. Helpman reaches interesting results which also deserve further theoretical and empirical investigations.

The model assumes that the north produces, saves, invests on research and innovates, however, the south only imitates northern innovations and produces. Imitation is assumed to be resource free, therefore does not bear any cost. Naturally, cost free imitation is a strong simplifying asumption, which ignores the fact that imitation cost may reach 65 percent of innovation cost of the same product. However, this figure changes in several sectors. Furthermore, the model assumes that, international capital market does not exist, and there is no risk for a patent to be obsolete. Imitation efforts of the south is the only risk for new technologies.

In this context, Helpman concludes that stronger patent protection always disturbs southern welfare level. On the other hand, northern welfare level depends on initial rate of imitation. Northern consumers also lose in the case of low imitation rate, but their welfare may improve otherwise. Therefore, small rate of imitation is globally optimum. Moreover, Helpman indicates that short term and long term results of the model are different, since tightening patent protection initially raises the rate of innovation in the north, but this figure is reversed in the long run.

The welfare analysis of the model has four parts, namely terms of trade, production composition, intertemporal allocation of consumption and availability of products. Stronger patent protection worsens all of these for the south, however there is a conflict between these for the north. Clearly, tightening patent protection improves terms of trade, but deteriorates production composition of the north. The temporal increment of the innovation rate in response to tightening patent protection is less than the detrimental results.

In summary, the model suggests that, a low level of imitation may be optimum for both the north and the south. However, policy implication of this result is difficult to apply, since patent policy strength and true imitation rate cannot be determined precisely. Moreover, externalities of innovative activities should be studied further. Sustainable growth of innovation seems to be achieved by only positive externality of innovations and its diffusions.

Helpman also models foreign direct investment in this context, and concludes that existence of foreign direct investment possibility reverses the welfare results for the north. Clearly, increasing strength of patent protection causes a welfare improvement for the north even in the case of low initial imitation rate. However, the same previous results are still valid for the south.

The patent protection system is one of the most examined of the IPRs protection policies. However, many firms also use alternative tools in order to consolidate protection of their new technologies. Naturally, alternative tools and their effectivenesses may change across industries. Taylor (1993) investigates one of these alternatives, namely masking, and builds a static partial equilibrium model which deals with north – south model of technology transfer. Masking efforts are widely applied in the form of encription, use of special materials and signs, copy protect schemes, and dummy codes, etc. Taylor considers imitation as a means of unintented technology transfer, and leaves licensed technology transfer and foreign direct investment outside the model. The model considers a duopoly structure without free entry and the northern and southern firms are assumed as first mover and follower respectively.

The model investigates the level of masking endogenously and suggests substitutability between official patent system and masking efforts. The north and the south are represented as an innovating, and imitating firm respectively. As is well known, northern firm invests in and develops high technology products, and southern firm invests in reverse engineering efforts in order to imitate these high technology products. Stringency of southern patent protection, which affects the level of masking in the north and the cost of imitation in the south, is the policy variable of the model. In this model setting, Taylor reports that, northern firm may compensate the decreasing stringency of southern patent protection by increasing masking efforts.

Therefore, the north may abonden the strategic movement of the south and keep its output unaffected which also indicates that southern output remains unchanged. Taylor also expresses that an increase in the stringency of southern patent protection raises the quality of imitation efforts. On the contrary, weak patent protection in the South causes little contribution to southern technology base.

In summary, Taylor concludes that patent protection system has two different faces in theory and in practice. Generally, theoretical studies ignore market created protection barriers for imitators, however, they are widely used in some industries. Moreover, stringeny of patent protection in the south and masking invesments in the north are substitutable implementations. On the other hand, these two implementations differ in northern profit terms. Clearly, weaker patent protection in the south decreases the profit of the northern firm, but may increase the profit of the southern firm. Naturally, this contradiction in the interests of the north and the south suggests that, an intermediate level of patent protection is globally optimum. Finally, Taylor also indicates that stringency of patent protection is a similar policy implementation as export subsidy.

Like stringency of patent protection, uniform patent protection across countries also deserves investigation, since asymmetric protection regimes may cause totally different results with respect to symmetric protection. Taylor (1994) builds a two country endogenous growth model corcerning two alternative patent regimes, namely symmetric and asymmetric protection between countries. The model allows continuum of products and international diffusion of knowledge. Whereas, gradation of patent strength is ignored, only two limiting alternative cases are considered. Clearly, in the first case, countries take domestic and foreign intellectual properties as the same and protect them equally. However, in the second case, home and foreign countries only protect their own intellectual properties. WTO member countries, which have to obey TRIPs requirements, are obligated to treat all countries equally. TRIPs agreement states that member countries cannot discriminate between other member countries, and have to obey most favoured nation principle. In this sense, symmetrical protection regime is guaranteed officially, but effects of asymmetrical protection regime should be further investigated, to discuss whether non-discrimination and most favoured nation principles are welfare optimum or not.

The model relates the patent protection regimes to pattern of trade and level of research, and investigates the effects on worldwide growth and welfare. Taylor states that ineffective patent protection may cause low level of investment on research, slow worldwide growth, and less technology transfer between countries.

Taylor concludes that, asymmetric patent protection may change the whole picture, clearly, it distorts trade in both product and research markets and creates a barrier to technology transfer and decreases relative wage in the R&D exporting country. Furthermore, R&D activities are slowing down in R&D exporting countries under asymmetric patent protection, and both domestic and foreign countries' welfare levels are damaged. In summary, asymmetric protection regimes distort natural trade pattern and decrease the level of R&D investment which causes slower worldwide economic growth.

The TRIPs agreement implies that signatory countries have to comply with minimum requirements of internationally accepted patent protection standarts. Moreover, non-discrimination principle of GATT is also an obligation for member countries which indicates that member countries have to treat both domestic and foreign patent holders equally. Clearly, TRIPs agreement requires uniform patent protection in world scale with only two exceptions. The first is a transition period[80] for developing and less developed countries. The second is that, member countries might set higher standards[81] for their national treatment, however non-discrimination principle is still an obligation. However, several patent protection standards exist in practice, in addition, some member countries violate non-discrimination principle of the GATT. For example, United States and European Union have higher protection standards for their national patents. This observation indicates a controversy among developed countries whether a uniform patent protection in all parties is welfare optimum or not. Proponents of discrimination argue that, higher internal patent protection standards

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80 Actually most favored nation principle is also binding in the transition period, whereas existing structure of national patent laws may create a natural barrier for foreigners.

81 The TRIPS agreement requires members to comply with certain minimum standards for the protection of IPRs covered in it, but members may choose to implement more extensive protection in their laws than is required in the agreement, provided that such protection does not contravene with the other provisions of the agreement.

promote domestic inventive activities, and do not damage foreign researches. Aoki and Prusa (1993) examine the effects of alternative patent protection on inventive activities worldwide. Their model is based on two firms - two countries R&D game and consists of four factors, namely relative efficiency of the firms, cost levels of R&D, pre-existing products and finally the value of innovation.

The model indicates that, discriminatory patent protection may be used to promote domestic R&D for the infant industry. On the other hand, foreign R&D investments decrease in response to discrimination. Moreover, if the size of innovation is larger relative to its cost, then discrimination would yield better results for domestic markets again. Finally, if domestic R&D activities are more efficient with respect to foreign R&D, then uniform patent protection standard is beneficial for the home country. In the light of their findings, Aoki and Prusa conclude that, discrimination is not always beneficial for discriminating country's R&D activities. In addition, they point that potential retaliation response of foreign country is ignored in the model which may further worsen the position of discriminating country. Aoki and Prusa indicate that, worldwide discrimination case should also be investigated to understand the whole picture.

In spite of these, GATT states and forces minimum protection standards and non-discrimination principle. The model has some missing parts, namely welfare analysis, counter measures of foreign government, multi-country modeling and dynamic nature of innovation. Nevertheless, the model implies that asymmetric patent protection may not be preferred to symmetric protection under specific settings.

To sum up this section, it is difficult to conclude that there is an agreement in literature on the relative importance of pros and cons of intellectual property protection. This clearly reveals that more research is needed in this subject. However, complexity of the subject and interaction with the other subject make it inconclusive. In any case, it may be stated that research and development activities should be supported without disturbing competition too much.

3.4.2 Role of TRIPs Agreement on FDI

As mentioned before, TRIPs agreement requires stronger protection for intellectual property rights in developing countries. Developing countries argue that stronger protection regime creates welfare loss for them, since they have strict comparative disadvantage in inventive activities. An important provision for least-developed countries is Article 66.2[82], which requires developed countries to provide incentives to promote technology transfer to least developed countries. In this framework, foreign direct investment seems to be one of the most effective ways of technology transfer.

Primo Braga, Fink and Sepulveda (1999) report the increasing importance of FDI. Clearly inward FDI is 4.6 percent of world gross domestic product in 1980, which reaches 10.1 percent in 1995. This indicates that FDI stock is doubled nearly in a decade. The figure is more dramatic for developing countries, that is, FDI stock has increased nearly fourfold between 1980 and 1995. On the other hand, there is no clear evidence at hand, which points that these increases are based on the developments of intellectual property protection. In fact, China[83] is an obvious counter example, that is, China is one of the major FDI receiving countries, but its IPRs protection system is very weak. China is receiving 18.2 percent of its gross domestic product as an inward FDI stock in 1995. Therefore, one should be careful when determining the effects of TRIPs agreement on FDI. In fact Maskus (1993) points that, choice among FDI, license and trade is complex and depends on a variety of strategic factors. Moreover, Maskus also reports that, most of the global expansion in foreign investment has been within the industrial countries.

Maskus indicates that there is no direct relation between FDI and IPRs protection systems, but he mentions two possible motivations for local governments of developing countries, which regulate stronger IPRs regimes. The first one is, some firms in developing countries seem to have developed a greater awareness of potential

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[82] Article 66.2 states that "developed country members shall provide incentives to enterprises and institutions in their territories for the purpose of promoting and encouraging technology transfer to least-developed country members in order to enable them to create a sound and viable technological base".

[83] China has changed its intellectual property legislation recently.

benefits of stronger protection, including greater incentives for local innovation and more access to foreign technology. These firms may be gaining political influence in national debates over technology policies. Second, local governments may use stronger IPRs protection regimes as a signal for invitation of multinational enterprises' investments. That is to say, it is suggested that enhanced IPRs protection would attract more FDI, because multinational enterprises may interpret it as a greater commitment by host country governments to establish and provide a mild investment environment for them.

In another study, Maskus (1997) states that strong IPRs protection alone is insufficient for generating strong incentives for firms to invest in a country. Both trade and competition policies of the host country are also effective. Maskus summarizes predictions about IPRs, FDI, and technology transfer between countries as follows. Firstly, FDI and technology transfer is expected to be insensitive to IPRs protection in old technology products and labor intensive technologies. Secondly, FDI inflow is sensitive to strength of IPRs protection in easily copied technologies such as pharmaceuticals, biotechnology and information technologies. Thirdly, it is also expected that stronger protection of IPRs may reduce the licensing costs. Finally, if an effective IPRs protection is guaranteed, the likelihood of most advanced technology transfer increases. Maskus' analysis indicates that, FDI flow is dependent on five groups of factors, namely macroeconomic factors[84], relative input costs, agglomeration effects[85], policy variables[86] and risk factors.

In this context, Ferrantino (1993) builds an econometric model and evaluates the role of IPRs on international trade and investment. He tries to explain the dependent variables (total export, sales, royalties and license fees) using three groups of data, namely, economic distance (distance, persons per telephone, political risk, colony dummy, Europe dummy), policy distance (tariff revenue, investment regime, foreign

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84 Market size, rate of growth of real GDP, and GNP per capita are the major FDI attracting macroeconomic factors.

85 Concentration of related economic activities in a location would decrease the production costs, thus attracting FDI into that location.

86 Tax rates, trade policy and level of domestic human capital effect FDI flow.

exchange regime, Paris and Berne Convention memberships, duration of patent) and other independent variables (unit labor costs, population and GDP). The findings can be summarized as follows. First, there is a weak association between countries' IPRs policies and their openness to trade and FDI. Second, there is no clear evidence about the relationship between IPRs regime and arms' length exports or affiliate sales. Third, transfer exports are significantly dependent on IPRs regimes. Fourth, receipts of royalties and license fees are higher in the case of strong IPRs regimes. In the light of these findings, Ferrantino concludes that the effect of IPRs on trade and investment should be studied further in order to be fully confirmed.

The early econometric studies show that there is no significant relationship between IPRs protection system and FDI flow[87]. Specifically, Kondo (1995) focuses on the patent protection. Kondo investigates the effects of patent protection on FDI using the American manufacturing FDI data and patent strength index[88] of 33 countries. He clearly concludes that, there is no evidence about the existence of an association between FDI and patent protection. In addition, Maskus and Eby Konan (1994) indicate that they could not find any evidence about the potential effects of TRIPs agreement. On the other hand, recent studies have found evidences of relationship, namely Lee and Mansfield (1996) and Maskus (1998). Lee and Mansfield report that there is a significant negative relationship between weaknesses of IPRs protection and American originated FDI. Maskus finds that American firms positively react to strength of patent system in FDI receiving countries. There is also evidence that a weak IPRs protection policy in FDI receiving country reduces the quality of technology transferred. Finally, there are indications that strengthening IPRs can increase the technology transfer and FDI inflow, but there are also other important factors which affect the decision of firms. Therefore, potential effects of the TRIPs agreement could not be assessed directly.

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87 See Mansfield (1993), Maskus and Eby Konan (1994) and Kondo (1995).

88 Kondo estimates a patent strength index, which covers the main national patent law provisions, namely patent life, exclusionary provisions (patentability of computer programs, pharmaceuticals, microbiological processes etc.) and scope provisions (cancellation for non-use, compulsory licensing, first to file system, patent infringements etc.).

CHAPTER 4

ECONOMICS OF PATENT PROTECTION

The purpose of the patent system is to reward innovators. Since rewards are based on the creation of market power, they necessitate welfare loss. The chapter discusses the tradeoff between the benefits associated with innovation and the costs of patent monopoly power. The problem is analyzed using first a partial equilibrium and thereafter a general equilibrium framework. The final section of the chapter deals with issues related with the inclusion of intellectual property rights through the so-called TRIPs Agreement into the WTO disciplines.

4.1 Partial Equilibrium

4.1.1 Theoretical Analysis

We follow Armington (1969) in defining the composite good q, called widgets, as a constant elasticity of substitution (CES) function of the different types of widgets X_i (i=1,..,n)

$$q = [\sum_{i=1}^{n} \alpha_i \, X_i^{\rho} \,]^{1/\rho} \, .$$

Let p_i (i = 1,..,n) be the price of the i-th widget. Consider the optimization problem

$$\max imize \ [\sum_{i=1}^{n} \alpha_i \, X_i^{\rho} \,]^{1/\rho} \, .$$

subject to the budget constraint $Y = \sum_{i=1}^{n} p_i X_i$, where Y denotes total expenditure on widgets. From the first order conditions we derive the demand functions for different types of widgets, assuming Y and prices p_i ($i = 1,..,n$) to remain fixed, as

$$X_i = \left(\frac{\alpha_i}{p_i}\right)^{\tau} \pi^{\tau-1} Y \qquad (i=1,..,n) \qquad (4.1)$$

where we define the following relationships:

$$\rho = [(\tau - 1)/\tau]$$

and

$$\pi = [\sum_{i=1}^{n} \alpha_i^{\tau} p_i^{1-\tau}]^{1/(1-\tau)} \qquad (4.2)$$

Here π is called CES dual price. It is the aggregate price of widgets and the parameter τ is called the substitution elasticity, which is derived from the relation

$$\frac{\partial(X_i/X_j)\,(p_i/p_j)}{\partial\,(p_i/p_j)\,(X_i/X_j)} = -\tau\,.$$

Let R_i denote the cost of innovating the i-th widget and let c_i be the constant unit cost of production of widget i after it has been invented. Finally, define demand for the composite good as

$$q = k_A\, \pi^{-\eta}$$

where η denotes the elasticity of demand for the composite good widget. Since by definition $Y = \pi\, q$ we have

$$Y = k_A\, \pi^{1-\eta} \qquad (4.3)$$

The above system of equations can be solved for the equilibrium values of prices and quantities once we specify the policy regimes. Following the approaches of Deardorff

(1992) and Panagariya (1999) we consider three policy regimes within our model settings: (i) an R&D subsidy that covers the cost of innovation but permits no patent protection, (ii) patent protection over T years during which time monopoly rights are granted to firms producing the widgets over these years and (iii) no protection at all.

Under the first policy regime the government gives R&D subsidy to the inventor to the full extend of the cost, raising the subsidy via a lump sum tax. Since the widget once invented can be produced at the constant marginal cost c_i the equilibrium price under perfect competition will equal the marginal cost. In Figure 4.1 DD' represents the demand for the i-th widget and c_i the constant marginal cost of production. Under the assumptions introduced, the equilibrium price will be c_i and equilibrium quantity X_i^*. The consumers' surplus during a given time period equals the area A + B + C under the demand curve while producers' surplus is 0. The net benefit to the society from the invention is the discounted value of consumers' surplus over the entire life of the product minus the cost of invention R_i.

Next consider the outcome under the patent. In this case the market for the i-th widget will be characterized by monopoly over the duration of patent life. The innovator will produce fewer i-th widgets and charge higher price than under competition. Maximization of profits yields the optimality condition that marginal revenue equals the marginal cost

$$p_i(1-\frac{1}{\varepsilon_i}) = c_i \qquad (4.4a)$$

where

$$\varepsilon_i = \tau - (\tau-1)\,\alpha_i^\tau\, p_i^{(1-\tau)}\,[\sum_{j=1}^{n}\alpha_j^\tau\, p_j^{1-\tau}]^{-1} \qquad (4.4b)$$

denotes the elasticity of demand for the i-th widget with respect to the i-th widget price p_i. In Figure 4.1 the monopoly equilibrium is shown by the price p_i^{mo} and quantity X_i^{mo}. The consumers' surplus during the time period t equals the area A under the demand curve while producers' surplus is B. Compared to the full R&D subsidy case consumers' surplus declines by the areas B and C. Producers' surplus rises by the area B. As a result the society suffers, relative to the R&D subsidy case, during each period a deadweight loss measured by the area C.

Finally we note that the product will not be innovated at all as long as the government does not subsidize innovation and nor grant a patent. The message given by consideration of this case is rather clear. As long as innovations are costly no one will engage in innovation unless the costs of innovation can be recovered.

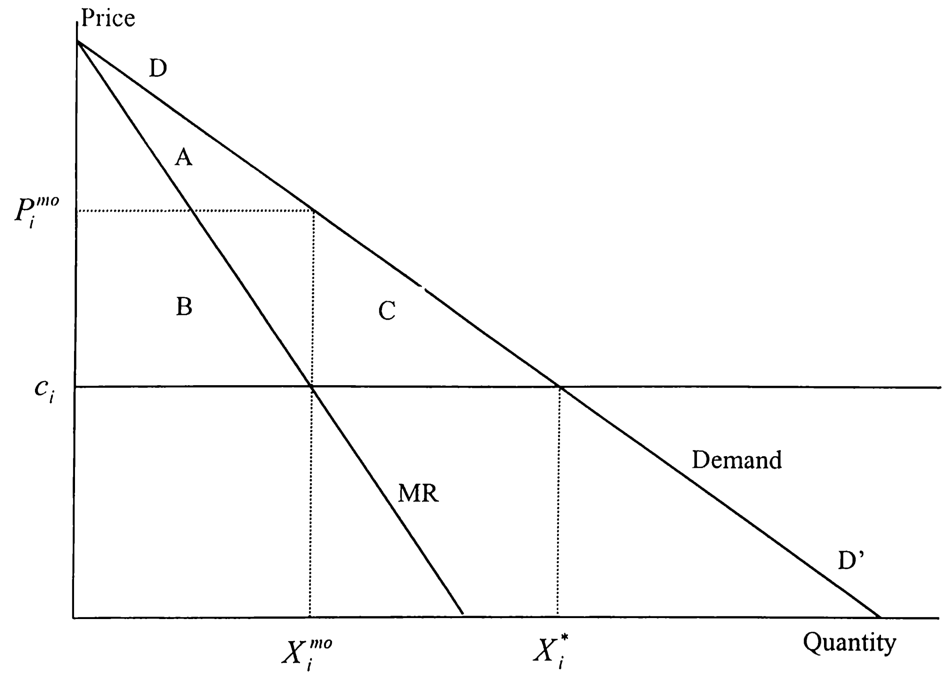

Figure 4.1

4.1.2 Numerical Analysis

In calibrating the model we scale the quantities so that perfectly competitive prices under R&D subsidy are all unity in the benchmark. This includes the price for the Armington composite good q. We assume that initially there are three varieties of widgets and that patents have expired for these widgets so that in equilibrium the prices of these widgets equal their marginal costs which in turn equal unity. Next consider the case of a single invention. We assume that the producer has designed a new product, a fourth widget, at a research cost of R_4. Once invented the fourth widget can be produced at the constant marginal cost c_4. We scale the quantity so that marginal cost c_4 equals unity. Finally we assume that different types of widgets are consumed in equal amounts and that the consumption of the fourth type of widget will equal that of the other widgets. Using the demand functions (4.1), the CES weight for each type of widget is determined as follows

$$\alpha_i = \left(\frac{X_i}{Y}\right)^{(1/r)} \qquad \text{(i=1,..,4)}$$

Table 4.1 presents the spreadsheet implementation of the Armington model with four types of widgets and Table 4.2 the formulas underlying the determination of monopoly equilibrium in Table 4.1. We assume that the product life of the widget is at least as long as the duration of the patent. Given the value of the elasticity of substitution we determine the price of the fourth widget for which marginal cost equals the marginal revenue using the SOLVER facility of MS Excel for Windows Program[89]. This case is denoted by "monopoly in sector 4" and shown on the left hand side of Table 4.1. On the other hand the solution of the case when government subsidizes the R&D in sector 4 is given on the right hand side of Table 4.1.

We consider three different values of total expenditure on widgets (1000, 2000 and 3000), five different values for the duration of patent (5, 10, 15, 20 and 25 years) and five different values of the elasticity of substitution (2, 4, 6, 8, 10). In each case we determine the discounted value of excess profits in sector 4 over the patent life under the assumption that at the end of patent duration the price of the commodity will fall down to the marginal cost so that there will be no excess profits after T years. The interest rate is assumed to be 5 percent[90].

The figures in Table 4.3 need some clarification. We assume that the cost of innovation underlying the Table 4.2 equals $R_4 = 500$. Dividing the discounted value of excess profits by cost of innovation we obtain the figures in Table 4.3a which indicate the discounted value of excess profits per unit of research cost in sector 4. Thus values below unity indicate situations where the discounted value of excess profit stream over the duration of the patent is less than the cost of the innovation.

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89 Microsoft Excel and Windows are trademarks of Microsoft Corporation.

90 The magnitude of numerical results are sensitive to changes in interest rate, however policy implications remain the same.

	A	B	C
1	**Table 4.1: Effects of Patent Protection in Subsector 4 only**		
2			
3		**MONOPOLY IN SECTOR 4**	**GOVERNMENT SUBSIDY TO R&D IN SECTOR 4**
4			
5	**Benchmark Values and Parameters**		
6	Benchmark Total Sales (Y, GY)	3000	3000
7	Number of Widgets in Sector 2 (n, Gn)	4	4
8	Benchmark Sales of X21 (S_1, GS_1)	750	750
9	Benchmark Sales of X22 (S_2, GS_2)	750	750
10	Benchmark Sales of X23 (S_3, GS_3)	750	750
11	Benchmark Sales of X24 (S_4, GS_4)	750	750
12	Elasticity of Demand - Composite Good (sq)	1,5	1,5
13	Elasticity of Substitution (st)	2	2
14	**Calibration**		
15	Share Parameter of X21 (a_1, Ga_1)	0,5000	0,5000
16	Share Parameter of X22 (a_2, Ga_2)	0,5000	0,5000
17	Share Parameter of X23 (a_3, Ga_3)	0,5000	0,5000
18	Share Parameter of X24 (a_4, Ga_4)	0,5000	0,5000
19			
20	**Patent Protection under Monopoly in Sector 4 only**		
21	Marginal Cost of X21 (MC1, GMC1)	1	1
22	Marginal Cost of X22 (MC2, GMC2)	1	1
23	Marginal Cost of X23 (MC3, GMC3)	1	1
24	Marginal Cost of X24 (MC4, GMC4)	1	1
25	Price of X21 (P_1, GP_1)	1	1
26	Price of X22 (P_2, GP_2)	1	1
27	Price of X23 (P_3, GP_3)	1	1
28	Price of X24 (P_4, GP_4)	2,1547	1
29	Composite Good Price (Pq, GPq)	1,1547	1,0000
30	The Term A (A, GA)	0,8660	1,0000
31	Total Expenditure on Composite Good (E, GE)	2791,8146	3000,0000
32			
33	Demand for X21 (D1, GD1)	805,93	750,00
34	Demand for X22 (D2, GD2)	805,93	750,00
35	Demand for X23 (D3, GD3)	805,93	750,00
36	Demand for X24 (D4, GD4)	173,59	750,00
37			
38	Price Elasticity in Sector 21 (sp1, Gsp1)	1,7113	1,7500
39	Price Elasticity in Sector 22 (sp2, Gsp2)	1,7113	1,7500
40	Price Elasticity in Sector 23 (sp3, Gsp3)	1,7113	1,7500
41	Price Elasticity in Sector 24 (sp4, Gsp4)	1,8660	1,7500
42			
43	Marginal Cost - Marginal Revenue in Sector 4 (MC_MR)	1,2097E-08	0,5714
44	Price - Marginal Cost in Sector 4 (P_MC)	1,1547	0,0000
45			
46	**Profits in sector 4**		
47	Subsidy to R&D (SP)	0	
48	Monopoly (MP)	200,4433	
49			
50	Welfare Loss (WL)	332,7911	
51	Interest Rate (i)	0,05	
52			
53	**Present Value of Excess Monopoly Profits and Welfare Loss**		
54	**Patent Duration (in years)**	**PV of Excess Profit in Sector 4**	**PV of Welfare Loss**
55	**5**	867,81	1.440,81
56	**10**	1.547,77	2.569,72
57	**15**	2.080,53	3.454,26
58	**20**	2.497,97	4.147,31
59	**25**	2.825,04	4.690,34

	A	B	C
1	**Table 4.2: Effects of Patent Protection in Subsector 4 only (Formulas)**		
2			
3		**MONOPOLY IN SECTOR 4**	**GOVERNMENT SUBSIDY TO R&D IN SECTOR 4**
4			
5	**Benchmark Values and Parameters**		
6	Benchmark Total Sales (Y, GY)	3000	=Y
7	Number of Widgets in Sector 2 (n, Gn)	4	=n
8	Benchmark Sales of X21 (S_1, GS_1)	=Y/n	=GY/Gn
9	Benchmark Sales of X22 (S_2, GS_2)	=Y/n	=GY/Gn
10	Benchmark Sales of X23 (S_3, GS_3)	=Y/n	=GY/Gn
11	Benchmark Sales of X24 (S_4, GS_4)	=Y/n	=GY/Gn
12	Elasticity of Demand - Composite Good (sq)	1,5	=sq
13	Elasticity of Substitution (st)	2	=st
14	**Calibration**		
15	Share Parameter of X21 (a_1, Ga_1)	=(S_1/Y)^(1/st)	=(GS_1/GY)^(1/st)
16	Share Parameter of X22 (a_2, Ga_2)	=(S_2/Y)^(1/st)	=(GS_2/GY)^(1/st)
17	Share Parameter of X23 (a_3, Ga_3)	=(S_3/Y)^(1/st)	=(GS_3/GY)^(1/st)
18	Share Parameter of X24 (a_4, Ga_4)	=(S_4/Y)^(1/st)	=(GS_4/GY)^(1/st)
19			
20	**Patent Protection under Monopoly in Sector 4 only**		
21	Marginal Cost of X21 (MC1, GMC1)	1	1
22	Marginal Cost of X22 (MC2, GMC2)	1	1
23	Marginal Cost of X23 (MC3, GMC3)	1	1
24	Marginal Cost of X24 (MC4, GMC4)	1	1
25	Price of X21 (P_1, GP_1)	=MC1	=GMC1
26	Price of X22 (P_2, GP_2)	=MC2	=GMC2
27	Price of X23 (P_3, GP_3)	=MC3	=GMC3
28	Price of X24 (P_4, GP_4)	2,15470051406009	=GMC4
29	Composite Good Price (Pq, GPq)	((a_1^st)*(P_1^(1-st))+(a_2^st)*(P_2^(1-st))+(a_3^st)*(P_3^(1-st))+(a_4^st)*(P_4^(1-st)))^(1/(1-st))	((Ga_1^st)*(GP_1^(1-st))+(Ga_2^st)*(GP_2^(1-st))+(Ga_3^st)*(GP_3^(1-st))+(Ga_4^st)*(GP_4^(1-st)))^(1/(1-st))
30	The Term A (A, GA)	(a_1^st)*(P_1^(1-st))+(a_2^st)*(P_2^(1-st))+(a_3^st)*(P_3^(1-st))+(a_4^st)*(P_4^(1-st))	(Ga_1^st)*(GP_1^(1-st))+(Ga_2^st)*(GP_2^(1-st))+(Ga_3^st)*(GP_3^(1-st))+(Ga_4^st)*(GP_4^(1-st))
31	Total Expenditure on Composite Good (E, GE)	=Y*Pq^(1-sq)	=GY*GPq^(1-sq)
32			
33	Demand for X21 (D1, GD1)	=E*((a_1/P_1)^st*Pq^(st-1))	=GE*((Ga_1/GP_1)^st*GPq^(st-1))
34	Demand for X22 (D2, GD2)	=E*((a_2/P_2)^st*Pq^(st-1))	=GE*((Ga_2/GP_2)^st*GPq^(st-1))
35	Demand for X23 (D3, GD3)	=E*((a_3/P_3)^st*Pq^(st-1))	=GE*((Ga_3/GP_3)^st*GPq^(st-1))
36	Demand for X24 (D4, GD4)	=E*((a_4/P_4)^st*Pq^(st-1))	=GE*((Ga_4/GP_4)^st*GPq^(st-1))
37			
38	Price Elasticity in Sector 21 (sp1, Gsp1)	=st-(st-1)*(a_1^st)*(P_1^(1-st))*A^(-1)	=st-(st-1)*(Ga_1^st)*(GP_1^(1-st))*GA^(-1)
39	Price Elasticity in Sector 22 (sp2, Gsp2)	=st-(st-1)*(a_2^st)*(P_2^(1-st))*A^(-1)	=st-(st-1)*(Ga_2^st)*(GP_2^(1-st))*GA^(-1)
40	Price Elasticity in Sector 23 (sp3, Gsp3)	=st-(st-1)*(a_3^st)*(P_3^(1-st))*A^(-1)	=st-(st-1)*(Ga_3^st)*(GP_3^(1-st))*GA^(-1)
41	Price Elasticity in Sector 24 (sp4, Gsp4)	=st-(st-1)*(a_4^st)*(P_4^(1-st))*A^(-1)	=st-(st-1)*(Ga_4^st)*(GP_4^(1-st))*GA^(-1)
42			
43	Marginal Cost - Marginal Revenue in Sector 4 (MC_MR)	=MC4-P_4*(1-(1/sp4))	=GMC4-GP_4*(1-(1/Gsp4))
44	Price - Marginal Cost in Sector 4 (P_MC)	=P_4-MC4	=GP_4-GMC4
45			
46	**Profits in sector 4**		
47	Subsidy to R&D (SP)	0	
48	Monopoly (MP)	=(P_4-MC4)*D_4	
49			
50	Welfare Loss (WL)	=(1/2)*(GD_4-D_4)*(P_4-GP_4)	
51	Interest Rate (i)	0,05	
52			
53		**Present Value of Excess Monopoly Profits and Welfare Loss**	
54	**Patent Duration (in years)**	**PV of Excess Profit in Sector 4**	**PV of Welfare Loss**
55	5	=PV(i;A55;-MP)	=PV(i;A55;-WL)
56	10	=PV(i;A56;-MP)	=PV(i;A56;-WL)
57	15	=PV(i;A57;-MP)	=PV(i;A57;-WL)
58	20	=PV(i;A58;-MP)	=PV(i;A58;-WL)
59	25	=PV(i;A59;-MP)	=PV(i;A59;-WL)

As a result the product will not be innovated under the patent system. In those cases where the values are less than unity the producers will not apply for patent protection. Producers will apply for patent protection only in those cases where the values in Table 4.3a equal to or exceed unity. The results in Table 4.3a and 4.3b are plotted in Figure 4.2 and 4.3 respectively, only for the first case which is, total expenditure on all types of widgets amounts to 1000. A close consideration of the figures in Table 4.3a reveals the following aspects:

- For any given level of patent duration and market size, producers' net benefit derived from patent protection decreases with increases in the value of the elasticity of substitution. The patent system is sensitive to changes in value of the elasticity of substitution and producers will be reluctant to innovate the product for larger values of the elasticity of substitution.

- For any given level of the elasticity of substitution and market size, producers' net benefit increases with increases in the duration of the patent. The patent system is sensitive to changes in the duration of patents. Producers reluctant to innovate the product will be induced to innovate the product and apply for protection with increases in the duration of patents.

- For any given level of the elasticity of substitution and duration of patent, producers' net benefit increases with increases in the market size. The patent system is sensitive to changes in the market size. Producers reluctant to innovate the product will be induced to innovate the product and apply for protection with increases in the market size.

Consider the case when expenditures on all types of widgets equal 2000, elasticity of substitution is 6 and patent length is 15 years. In this case the producer will not innovate the product. The producer will innovate the product when either the market size increases to 3000 or when elasticity of substitution decreases to 4, or when patent length increases to 25 years.

Table 4.3b showing the present value of the welfare loss approximated by the area C in Figure 4.1 reveals the following aspects

- For any given level of patent duration and market size, present value of the welfare loss derived from patent protection increases with decreases in the value of the elasticity of substitution. The welfare loss is sensitive to changes in value of the elasticity of substitution.

- For any given level of the elasticity of substitution and market size, present value of the welfare loss increases with increases in the duration of the patent. The welfare loss is sensitive to changes in the duration of patents.

- For any given level of the elasticity of substitution and duration of patent, present value of the welfare loss increases with increases in the market size. The welfare loss is sensitive to changes in the market size.

Comparison of the figures in Table 4.3 reveal that the welfare cost of patents is substantial in all cases where the present value of excess profits exceeds the cost of innovation. Cases where the welfare cost of patents are relatively low refer to cases[91] where the present value of excess profits falls short of the cost of innovation.

The upper part of Table 4.4a shows the discounted value of excess profits in sector 4 per unit of research cost for the case when expenditure on different types of widgets remains constant. The lower part of the table is derived under the assumption that the producer of widget 4 has managed to obtain patent rights not only for widget 4 but also for widget 3. In this case we assume that patents have expired for the first two widgets. The table reveals that for given levels of patent duration, elasticity of substitution and market size, the producers' net benefit derived from patent protection increases as the firm obtains patent rights for close substitutes (widget 3). On the other hand Table 4.4b shows the figures for the present value of the welfare loss. The lower part of the table is derived again under the assumption that the producer of widget 4 has managed to obtain patent rights not only for widget 4 but also for widget 3. The table shows that for given levels of patent duration, elasticity of substitution and market size, the present value of the welfare loss in sector 4 decreases as the firm obtains patent rights for close substitutes.

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[91] Actually in these cases, product would not be innovated under patent protection.

Table 4.3a: Effects of Changes in Duration of Patents, Elasticity of Substitution and Market Size on discounted value of profits per unit of research cost in sector 4

Case 1: Expenditure on all types of widgets amounts to 1000

	Elasticity of Substitution				
Duration	2	4	6	8	10
5	0,579	0,261	0,169	0,124	0,099
10	1,032	0,466	0,301	0,222	0,176
15	1,387	0,626	0,404	0,298	0,236
20	1,665	0,751	0,485	0,358	0,284
25	1,883	0,850	0,549	0,405	0,321

Case 2: Expenditure on all types of widgets amounts to 2000

5	1,157	0,522	0,337	0,249	0,197
10	2,064	0,931	0,601	0,444	0,352
15	2,774	1,252	0,808	0,597	0,473
20	3,331	1,503	0,970	0,716	0,568
25	3,767	1,699	1,097	0,810	0,642

Case 3: Expenditure on all types of widgets amounts to 3000

5	1,736	0,783	0,506	0,373	0,296
10	3,096	1,397	0,902	0,666	0,528
15	4,161	1,877	1,212	0,895	0,709
20	4,996	2,254	1,455	1,074	0,852
25	5,650	2,549	1,646	1,215	0,963

Table 4.3b: Effects of Changes in Duration of Patents, Elasticity of Substitution and Market Size on the Present Value of Welfare Loss in sector 4

Case 1: Expenditure on all types of widgets amounts to 1000

5	480,27	138,22	79,23	55,34	42,47
10	856,57	246,52	141,30	98,70	75,75
15	1151,42	331,38	189,94	132,67	101,83
20	1382,44	397,87	228,05	159,29	122,26
25	1563,45	449,96	257,91	180,14	138,26

Case 2: Expenditure on all types of widgets amounts to 2000

5	960,54	276,45	158,45	110,68	84,94
10	1713,15	493,05	282,61	197,39	151,50
15	2302,84	662,76	379,88	265,34	203,65
20	2764,87	795,74	456,10	318,58	244,51
25	3126,89	899,93	515,82	360,29	276,53

Case 3: Expenditure on all types of widgets amounts to 3000

5	1440,81	414,67	237,68	166,01	127,42
10	2569,72	739,57	423,91	296,09	227,25
15	3454,26	994,14	569,83	398,01	305,48
20	4147,31	1193,61	684,16	477,86	366,77
25	4690,34	1349,89	773,74	540,43	414,79

Table 4.4a: Effects of Increasing Patent Rights to Close Substitutes on the discounted value of profits per unit of research cost in sector 4 when expenditure on different types of widgets amount to 2000

Case: Patent granted to sector 4 only

	Elasticity of Substitution				
Duration	2	4	6	8	10
5	1,157	0,522	0,337	0,249	0,197
10	2,064	0,931	0,601	0,444	0,352
15	2,774	1,252	0,808	0,597	0,473
20	3,331	1,503	0,970	0,716	0,568
25	3,767	1,699	1,097	0,810	0,642

Case: Patents granted to sectors 3 and 4

5	1,259	0,619	0,408	0,304	0,243
10	2,245	1,103	0,728	0,543	0,433
15	3,018	1,483	0,979	0,730	0,582
20	3,623	1,781	1,175	0,876	0,699
25	4,098	2,014	1,329	0,991	0,790

Table 4.4b: Effects of Increasing Patent Rights to Close Substitutes on the present value of welfare loss in sector 4 when expenditure on different types of widgets amount to 2000

Case: Patent granted to sector 4 only

	Elasticity of Substitution				
Duration	2	4	6	8	10
5	960,54	276,45	158,45	110,68	84,94
10	1713,15	493,05	282,61	197,39	151,50
15	2302,84	662,76	379,88	265,34	203,65
20	2764,87	795,74	456,10	318,58	244,51
25	3126,89	899,93	515,82	360,29	276,53

Case: Patents granted to sectors 3 and 4

5	969,160	263,170	147,050	101,290	77,070
10	1728,510	469,380	262,270	180,660	137,460
15	2323,490	630,940	352,550	242,850	184,770
20	2789,670	757,540	423,280	291,570	221,850
25	3154,940	856,720	478,700	329,750	250,890

Figure 4.2. Ratio of Monopoly profit to R&D cost (Expenditure on all types of widgets amounts to 1000)

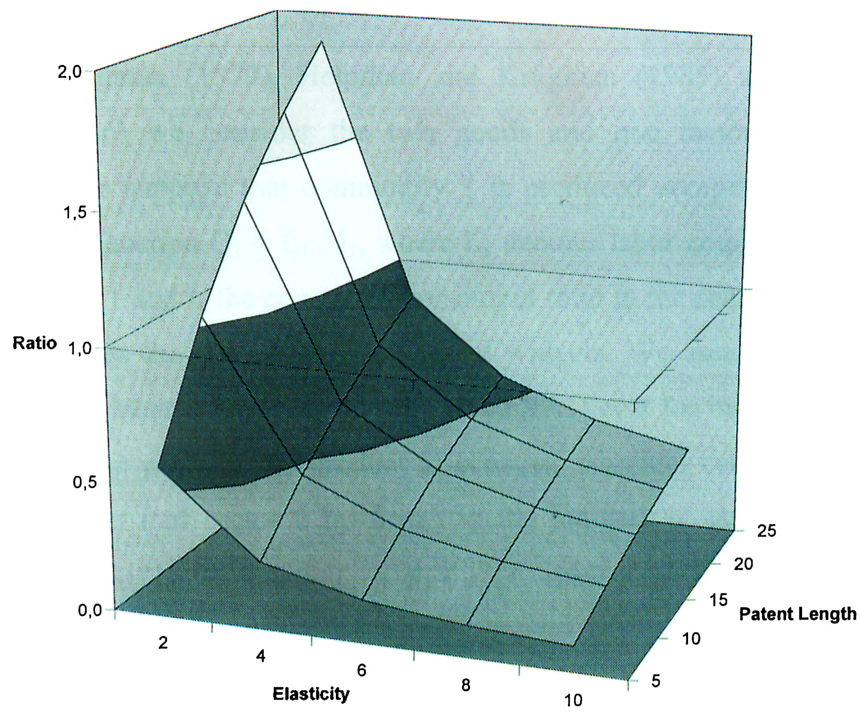
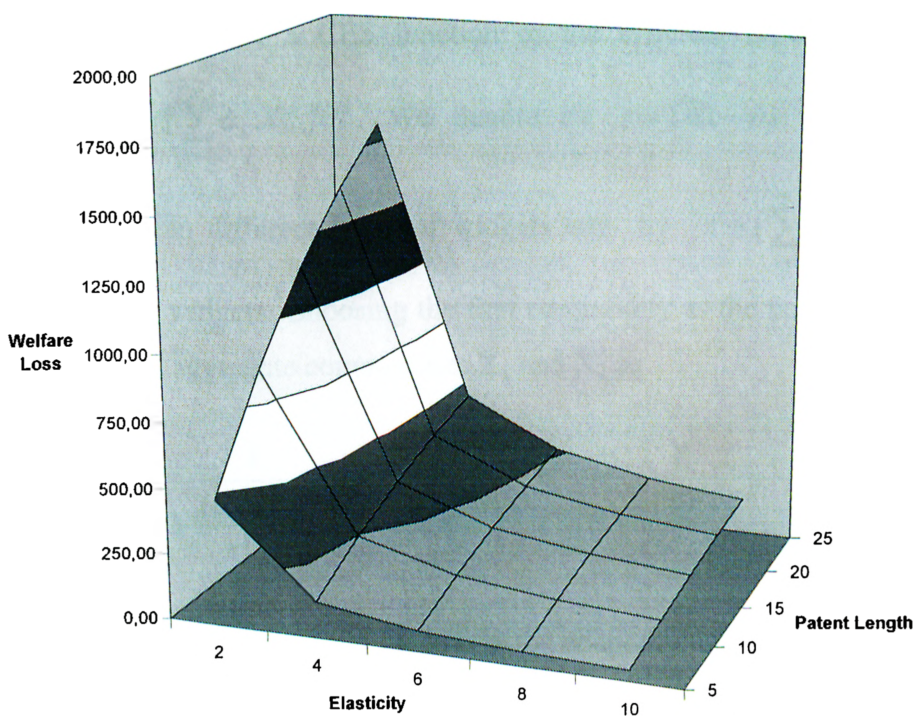


Figure 4.3. Welfare Loss in Sector 4 (Expenditure on all types of widgets amounts to 1000)



4.2. General Equilibrium

4.2.1 Theoretical Analysis

Following Krugman (1979), Helpman and Krugman (1985) and Horstmann and Markusen (1986) we consider the two goods and one factor model of general equilibrium. We suppose that commodity 1 is produced competitively according to the production function $Q_1 = L_1 / l_1$, where L_1 denotes labor employed in sector 1, Q_1 output of sector 1 and l_1 the constant labor-output ratio in the same sector. The second industry produces the composite good called widgets. We assume that firms in the second industry incur initially some large fixed R&D cost for innovating the product, but thereafter can produce the product at constant marginal cost. The labor used in producing widget i of sector 2 by firm i in the industry is assumed to be a linear function of output, i.e. it equals $L_{2i} = R_i + c_i Q_{2i}$ during the initial time period when the product is innovated, and $L_{2i} = c_i Q_{2i}$ thereafter.

We assume that community preferences can be represented by the utility function $u = [a X_1^{\beta} + b X_2^{\beta}]^{1/\beta}$ where $\theta = 1/(1-\beta)$ denotes the elasticity of substitution between commodity 1 and composite good X_2. The composite good widgets is assumed to be as before a CES function of the different types of widgets X_{2i} (i=1,..,n): $X_2 = [\sum_{i=1}^{n} \alpha_i X_{2i}^{\rho}]^{1/\rho}$. We denote by $\tau = 1/(1-\rho)$ the elasticity of substitution between different types of widgets and by $\pi = [\sum_{i=1}^{n} \alpha_i^{\tau} p_i^{1-\tau}]^{1/(1-\tau)}$ the aggregate price of widgets. Choosing the first commodity as the numeraire we obtain the demand for the aggregate commodities X_1 and X_2 as

$$X_1 = \frac{Y}{(1 + \dfrac{(b/a)^{(1/(1-\beta))}}{\pi^{(\beta/(1-\beta))}})} \quad \text{and} \quad X_2 = \frac{Y}{\pi(1 + \dfrac{(\pi)^{\beta/(1-\beta)}}{(b/a)^{1/(1-\beta)}})} \qquad (4.4)$$

where $Y = X_1 + \pi X_2$ denotes total income in the economy. Under perfect competition in sector 1 the price equation reduces to $w\, l_1 = p_1$ where w denotes the wage rate and p_1 the price of commodity 1. We choose the first commodity as the numeraire. Hence we get $w = 1/l_1$ indicating that wage rate equals the marginal product of labour in sector 1. The cost of producing commodity 2i by firm i (i=1,...,n) can now be specified as $C^i = wL_2^i = \frac{R_i}{l_1} + \frac{c_i}{l_1} Q_{2i}$ during the initial time period when the product is innovated, and as $C^i = wL_2^i = \frac{c_i}{l_1} Q_{2i}$ thereafter.

We assume that all firms are alike so that $R_i = R$ and $c_i = c$ for all i (i=1,..,n). Given the total labor supply L in the economy and the number of widgets n, the equation of the production possibility frontier of the economy for the period under consideration is written as $Q_1 = (L / l_1) - (c / l_1)\,[Q_{21} + .. + Q_{2n}]$ as long as all of the n widgets have been innovated in the previous periods. In the case the (n-1) widgets were innovated in the previous periods and the n-th widget were to be innovated during the time period under consideration, the equation of the production possibility frontier of the economy becomes: $Q_1 = (L / l_1) - (R / l_1) - (c / l_1)\,[Q_{21} + .. + Q_{2n}]$.

Denoting total expenditure on widgets by $Z = \pi X_2$ we obtain the demand functions for the n widgets as

$$X_i = \left(\frac{\alpha_i}{p_i}\right)^r \pi^{r-1} Z \qquad (i=1,..,n) \qquad (4.5)$$

The above system of equations can be solved for the equilibrium values of prices and quantities once we specify the policy regimes. Following the approaches of Deardorff (1992) and Panagariya (1999) we consider as before three policy regimes: (i) an R&D subsidy that covers the cost of innovation but permits no patent protection, (ii) patent protection over T years during which time monopoly rights are granted to firms producing the widgets and (iii) no protection at all.

Under the first policy regime the widget once invented can be produced at the constant marginal cost (c / l_1). The equilibrium price under perfect competition will equal its marginal cost. When determining equilibrium in the model we scale the quantities so that perfectly competitive prices of all widgets under R&D subsidy are all unity. As a result the aggregate price of widgets π is also unity. Under full employment of labor, income Y in the economy equals the labor supply L. Given Y we determine the demands for X_1 and X_2 from (4.4) and hence $Z = \pi X_2$ Given Z the demand for the various types of widgets is determined from (4.5). The solution under R&D subsidy is then obtained by setting the outputs of widgets Q_{2i} equal to demand for widget X_{2i} (i=1,..,n).

On the other hand the equilibrium with patents is characterized as follows. We assume that patents for all of the (n-1) widgets have been granted during the previous periods and that these patents have expired so that the prices of these (n-1) widgets under competition equal their marginal costs. The market for the n-th widget is characterized by monopoly over the duration of patent life. Compared to the case under R&D subsidy, the innovator of the n-th widget will produce fewer widgets and charge higher price. Maximization of profits yields the optimality condition that marginal revenue equals the marginal cost $p_n(1-\frac{1}{\varepsilon_n})=(c/l_1)$ where $\varepsilon_n=\tau-(\tau-1)\alpha_n^r p_n^{(1-r)}[\sum_{j=1}^{n}\alpha_j^r p_j^{1-r}]^{-1}$ denotes the elasticity of demand for the n-th widget with respect to the n-th widget price p_n. When determining the equilibrium in the model we again scale the quantities so that marginal costs of the n widgets are all unity. Income Y in the economy is defined as $Y = Q_1 + p_{21} Q_{21} + .. + p_{2n} Q_{2n}$.

Given Y, we determine the aggregate price of widgets as $\pi=[\sum_{i=1}^{n}\alpha_i^r p_i^{1-r}]^{1/(1-r)}$, demands for X_1 and X_2 from (4.4) and hence the value of expenditures on X_2 as $Z = \pi X_2$. Given Z the demand for the various types of widgets is determined from (4.5). The solution under patent is then obtained by setting the outputs of widgets Q_{2i} equal to demand for widget X_{2i} (i=1,..,n) and by imposing the condition that marginal revenue equals the marginal cost in the sector for the n-th widget, i.e.

$$p_n(1-\frac{1}{\varepsilon_n})=(c/l_1).$$

Given the equilibrium price of the n-th widget and its marginal cost (c/ l_1), excess profits per unit of output is defined as (p_n - (c/ l_1)) and excess profits during period t is given as $\Pi_{nt} = (p_n - (c/ l_1)) * Q_{2nt}$. Given the rate of interest r, which we assume to stay constant over time, the present value of excess profits over the duration of the patent is determined by the relation $\sum_{t=1}^{T} \frac{\Pi_{nt}}{(1+r)^t}$. We assume that at the end of patent duration the price of the commodity will fall down to its marginal cost so that there will be no excess profits after T years.

4.2.2 Welfare Analysis

To assess the welfare costs of patents we introduce the concept of a hypothetical level of expenditures $\overline{Y^{patent}}$, defined as the level of expenditures that households would require if, at the prices prevailing under R&D subsidy, the households are to enjoy the same level of welfare as they would under patent protection. Letting p^{comp} and p^{patent} be the price vector of widgets under R&D subsidy and patent protection respectively, measured in terms of the first commodity, and Y^{comp} and Y^{patent} the level of income under R&D subsidy and patent protection, we have $u(p^{comp}, \overline{Y^{patent}}) = u(p^{patent}, Y^{patent})$.

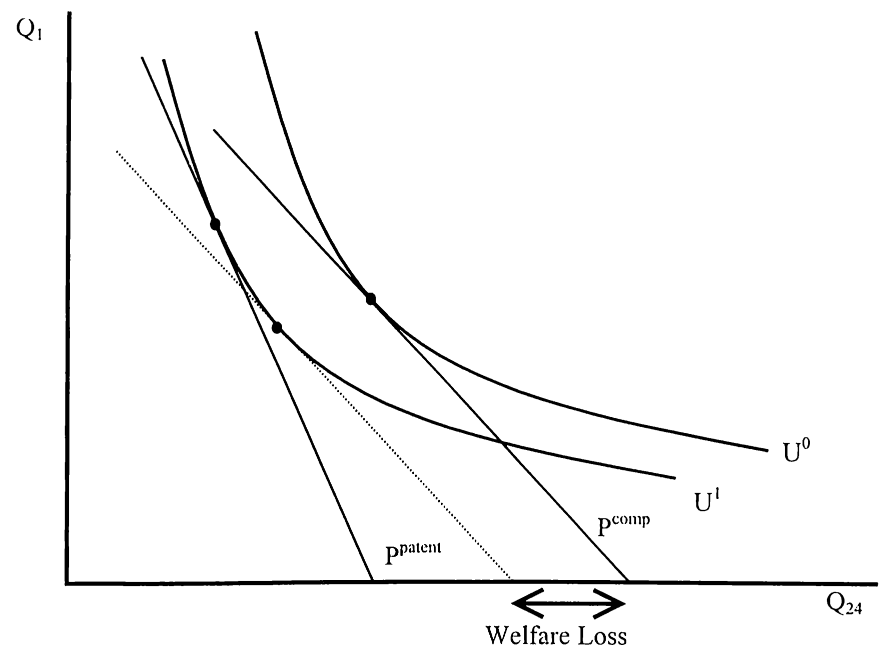


Figure 4.4 Welfare Analysis (Equivalent Variation)

The welfare loss due to patents at any moment of time can now be evaluated by the welfare loss defined by Welfare Loss = $Y^{comp} - \overline{Y^{patent}}$.

Next, we determine the discounted value of welfare loss over the patent life under the assumption that at the end of patent duration the price of the commodity will fall down to the marginal cost so that there will be no more welfare loss after T years.

Finally we again note that the product will not be innovated[92] at all as long as the government neither subsidizes innovation, nor grant a patent. The message given by consideration of this case is rather clear. As long as innovations are costly no one will engage in innovation unless the costs of innovation can be recovered.

4.2.3 Numerical Analysis

In calibrating the model we scale the quantities so that perfectly competitive prices under R&D subsidy are all unity in the benchmark. This includes the aggregate price π of widgets. Using the demand functions (4.5), the CES weight for each type of widget is determined as follows

$$\alpha_i = \left(\frac{X_i}{Y}\right)^{(1/r)} \qquad \text{(i=1,..,n)}$$

Table 4.5 presents the spreadsheet implementation of the general equilibrium model with four types of widgets. We assume that the product life of the widget is at least as long as the duration of the patent. Given the values of the parameters we determine equilibrium under patent using the SOLVER facility of Microsoft Excel Program. The case of "patent protection" is shown on the right hand side and the case when government subsidizes the R&D is given on the left hand side of the Table 4.5.

We consider four types of widgets. We consider five different values for the duration of patent (T=5, T=10, T=15, T=20 and T=25 years) and five different values for the elasticity of substitution (τ=2, τ=4, τ=6, τ=8, τ=10). The demand structure for aggregate commodities X_1 and X_2 is given by the parameters (a=0.875, b=0.125, β= (1/3)). In each case we determine the discounted value of excess profits in the n-th widget sector over the patent life. Similar considerations apply for determination of

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[92] In this case, there is no innovation, production or consumption of widgets. This means net welfare gain is zero from innovation.

the welfare cost. Finally, we assume that the interest rate stays constant at 5 percent over the period.

The figures in Table 4.6a need some clarification. The figures in the table have been obtained by dividing the discounted value of excess profits by the cost of innovation, which we assume to amount to 200. Thus values below unity in Table 4.6a indicate situations where the discounted value of excess profit stream in sector 24 over the duration of the patent is less than the cost of the innovation. As a result the product in those cases will not be innovated under the patent system. Producers will apply for patent protection only in those cases where the values in Table 4.6a equal to or exceed unity.

In the table we assume in the first two cases that demand pattern for the consumption of widgets remains unchanged. In particular we assume in cases 1 and 2 that the four widgets are consumed in the proportions (10, 20, 60, 10) indicating that the share of e.g. the third widget in total expenditure on widgets in the benchmark is 60 percent. On the other hand in the case 3 of Table 4.6 we assume that the widget demand pattern changes. In particular we assume that demand for fourth widget decreases[93]. Inspired by the approach of Diwan and Rodrik[94] (1991) we assume that the proportions become (20, 60, 18, 2) indicating that the share of e.g. the fourth widget in total expenditure on widgets has decreased from 10 to 2 percent. A close consideration of the figures in Table 4.6a reveals the following aspects:

- For any given level of patent duration, market size, and demand pattern, producers' net benefit derived from patent protection decreases with increases in the value of the elasticity of substitution. The patent system is sensitive to changes in value of the elasticity of substitution τ. Producers will be reluctant to innovate the product for relatively larger values of the elasticity of substitution τ.

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93 This case may arise due to existence of absorption lag of new technology by the society.

94 In fact, Diwan and Rodrik clearly proposed that there may be differences between the needs or tastes of the North and the South. According to them, the South may need drugs for tropical diseases, whereas the North may need drugs for cancer. In this study, their idea about the demand differences is evaluated within our model setting.

- For any given level of the elasticity of substitution, market size and demand pattern, producers' net benefit increases with increases in the duration of the patent T. The patent system is sensitive to changes in the duration of patents T. Producers reluctant to innovate the product will be induced to innovate the product and apply for protection with increases in the duration of patents.

- For any given level of the elasticity of substitution τ, duration of patent T and pattern of demand, producers' net benefit increases with increases in the market size. The patent system is sensitive to changes in the market size. Producers reluctant to innovate the product will be induced to innovate the product and apply for protection with increases in the market size.

- For any given level of the elasticity of substitution τ, duration of patent T, and market size, producers' net benefit decreases with decreases in the demand for the product under consideration. The patent system is sensitive to changes in the demand pattern. Producers reluctant to innovate the product will be induced to innovate the product and apply for protection with increases in the demand for the product.

Consider the case when income under R&D subsidy equals 20000, elasticity of substitution is 6, patent length is 15 years and demand pattern is (10, 20, 60, 10). In this case the producer will not innovate the product. The producer will innovate the product when either the market size increases to 60000 or when elasticity of substitution decreases to 2. In this case an increase in patent length even to 25 years will not affect the decisions of producers and the product will still not be innovated. The decision not to innovate will not change with a decrease in the demand for the product.

Table 4.6b showing the present value of the welfare loss reveals the following aspects

- For any given level of patent duration T, market size and pattern of demand, present value of the welfare loss derived from patent protection increases with decreases in the value of the elasticity of substitution τ. The welfare loss is sensitive to changes in value of the elasticity of substitution τ.

- For any given level of the elasticity of substitution τ, market size and pattern of demand, present value of the welfare loss increases with increases in the duration of the patent T. The welfare loss is sensitive to changes in the duration of patents T.

- For any given level of the elasticity of substitution τ, duration of patent T and pattern of demand, present value of the welfare loss increases with increases in the market size. The welfare loss is sensitive to changes in the market size.

- For any given level of the elasticity of substitution τ, duration of patent T, and market size, present value of welfare loss decreases with decreases in the demand for the product under consideration. The welfare loss is sensitive to changes in the demand pattern.

The figures in Table 4.6 also indicate the tradeoff between the benefits associated with innovation and the costs of patent monopoly power. The table reveals that the welfare cost of patents is substantial in all cases where the present value of excess profits exceeds the cost of innovation. Cases where the welfare cost of patents are relatively low refer to cases where the present value of excess profits falls short of the cost of innovation.

4.3. North-South Model

Consider the world as divided into two regions, North and South. Both regions are assumed to face the same cost of innovation R = 200, the same marginal cost of production (c/l_1), and similar demand structures ($a=0.875$, $b=0.125$, $\theta=1.5$)) for aggregate commodities X_1 and X_2. We suppose that governments in the two regions do not subsidize the R&D expenditures, and assume that each region is free to choose what it considers to be the optimal intellectual property rights regime for itself. The main difference between the two regions lies in the size of their labor forces. Total labor supply equals 60000 in the North and 20000 in the South.[95]

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[95] One could assume that the North has comparative advantage in innovations by requiring that the cost of innovation in the North R^n is smaller than the cost of innovation in the South R^s, or that the marginal cost of production in the North c^n is smaller than the marginal cost of production in the South c^s. In the text, none of these assumptions are introduced.

	A	B	C	D
1	**Table 4.5: Effects of Patents**			
2				
3	**Parameters**		**Parameters**	
4	Labor Coefficient in Sector 1 (l_1)s	1,00	Benchmark Total Sales in Sector 2 (X_2)	100
5	Labor Coefficient in Sector 21 (c_1)	1,00	Benchmark Sales of X21 (BX_21)	10
6	Labor Coefficient in Sector 22 (c_2)	1,00	Benchmark Sales of X22 (BX_22)	20
7	Labor Coefficient in Sector 23 (c_3)	1,00	Benchmark Sales of X23 (BX_23)	60
8	Labor Coefficient in Sector 24 (c_4)	1,00	Benchmark Sales of X24 (BX_24)	10
9	Fixed R&D Cost (RD)	200,00	Total Labor Supply (L)	60000
10	Coefficient of CES Utility Function for Sector 1 (a)	0,875	Interest Rate (i)	0,05
11	Coefficient of CES Utility Function for Sector 2 (b)	0,125		
12	Elasticity of Subs. in the CES Utility (sCES) θ	1,5	**Calibration**	
13	Elasticity of Subs. Parameter of the Utility (pCES) β	0,3333	Share Parameter of X21 (a_21)	0,3162
14	Elasticity of Subs. in the CES Sub-Utility (sSub) τ	2	Share Parameter of X22 (a_22)	0,4472
15	Elasticity of Subs. Parameter of the Sub-Utility (pSub) ρ	0,5000	Share Parameter of X23 (a_23)	0,7746
16	Number of Firms in Sector 2 (n)	4	Share Parameter of X24 (a_24)	0,3162
17		**R&D Subsidy**	**Patent Protection**	
18	Q21 (Q_21, PPQ_21)	307,372968	316,426371	
19	Q22 (Q_22, PPQ_22)	614,745936	632,852743	
20	Q23 (Q_23, PPQ_23)	1844,237808	1898,558228	
21	Q24 (Q_24, PPQ_24)	307,372968	74,776113	
22	Q1 (Q_1, PPQ_1)	56926,27	57077,39	
23	Marginal Cost of Q21 (MC21, PPMC1)	1	1	
24	Marginal Cost of Q22 (MC22, PPMC2)	1	1	
25	Marginal Cost of Q23 (MC23, PPMC3)	1	1	
26	Marginal Cost of Q24 (MC24, PPMC4)	1	1	
27	Price of Q21 (P_21, PP_21)	1	1	
28	Price of Q22 (P_22, PP_22)	1	1	
29	Price of Q23 (P_23, PP_23)	1	1	
30	Price of Q24 (P_24, PP_24)	1	2,0541	
31	Composite Good Price (Pq, PPq)	1,0000	1,0541	
32	The Term A (TA, PPTA)	1,0000	0,9487	
33	Y, PPY	60000	60078,82	
34	Demand for X1 (D_1, PPD1)	56926,27	57077,07	
35	Demand for X2 (D_2, PPD2)	3073,73	2847,71	
36	Total Expenditure (Z, PPZ)	60000,00	60078,82	
37	Share of X2 in Total Income (SX2)	5,12	4,74	
38	Value of Expenditure on X2 (Z_2)	3073,7297	3001,75	
39	Demand for X21 (D_21, PD21)	307,3730	316,4127	
40	Demand for X22 (D_22, PD22)	614,7459	632,8255	
41	Demand for X23 (D_23, PD23)	1844,2378	1898,4764	
42	Demand for X24 (D_24, PD24)	307,3730	74,9918	
43	Price Elasticity in Sector 21 (sp1, PPsp1)	1,9000	1,8946	
44	Price Elasticity in Sector 22 (sp2, PPsp2)	1,8000	1,7892	
45	Price Elasticity in Sector 23 (sp3, PPsp3)	1,4000	1,3675	
46	Price Elasticity in Sector 24 (sp4, PPsp4)	1,9000	1,9487	
47	MC - MR in Sector 21 (MC_MR21, PMC_MR21)	0,5263	0,5278	
48	MC - MR in Sector 22 (MC_MR22, PMC_MR22)	0,5556	0,5589	
49	MC - MR in Sector 23 (MC_MR23, PMC_MR23)	0,7143	0,7312	
50	MC - MR in Sector 24 (MC_MR24, PMC_MR24)	0,5263	0,0000	
51	Sub-utility (sU, PPsU)	3073,73	2847,71	
52	Utility (U, PPU)	44653,19	44592,83	
53	ES_21, PES_21	0,0000	0,0136	
54	ES_22, PES_22	0,0000	0,0273	
55	ES_23, PES_23	0,0000	0,0818	
56	ES_24, PES_24	0,0000	-0,2157	
57	Price - MC in Sector 21 (P_MC21, PP_MC21)	0,0000	0,0000	
58	Price - MC in Sector 22 (P_MC22, PP_MC22)	0,0000	0,0000	
59	Price - MC in Sector 23 (P_MC23, PP_MC23)	0,0000	0,0000	
60	Price - MC in Sector 24 (P_MC24, PP_MC24)	0,0000	1,0541	
61	Income*	-	59918,91	
62	Expenditure* on X1	-	56849,33	
63	Expenditure* on X2	-	3069,58	
64	Demand for X21*	-	306,96	
65	Demand for X22*	-	613,92	
66	Demand for X23*	-	1841,75	
67	Demand for X24*	-	306,96	
68	Sub-utility*	-	3069,58	
69	Utility Difference	-	0,0000E+00	
70	Welfare Loss	-	81,0934	
71	**Excess Profit in Sub-sector 24**	79,04832708		
72	**Welfare Loss (WL)**	81,0934		
73				
74		**Present Value of Excess Monopoly Profits and Welfare Loss**		
75	**Patent Duration (in years)**	**PV of Excess Profit in Sector 4**	**PV of Welfare Loss**	
76	**5**	342,24	351,09	
77	**10**	610,39	626,18	
78	**15**	820,49	841,72	
79	**20**	985,12	1.010,60	
80	**25**	1.114,10	1.142,93	

Table 6a: Effects of Changes in Duration of Patents, Elasticity of Substitution and Market Size on discounted value of profits per unit of research cost in sector 4

Duration	Elasticity of Substitution 2	4	6	8	10
Case 1: Solution for the North					
5	1,711	0,739	0,472	0,347	0,274
10	3,052	1,317	0,841	0,618	0,489
15	4,102	1,771	1,131	0,831	0,657
20	4,925	2,126	1,358	0,998	0,789
25	5,570	2,405	1,536	1,128	0,892
Case 2: Solution for the South when demand pattern in the South equals that of the North					
5	0,570	0,246	0,157	0,116	0,091
10	1,017	0,439	0,280	0,206	0,163
15	1,367	0,590	0,377	0,277	0,219
20	1,642	0,709	0,453	0,333	0,263
25	1,857	0,802	0,512	0,376	0,297
Case 3: Solution for the South when demand pattern in the South is lagged on that of the North					
5	0,112	0,047	0,030	0,022	0,017
10	0,199	0,084	0,054	0,039	0,031
15	0,267	0,113	0,072	0,053	0,042
20	0,321	0,136	0,086	0,063	0,050
25	0,363	0,154	0,098	0,072	0,057

Table 6b: Effects of Changes in Duration of Patents, Elasticity of Substitution and Market Size on welfare cost in sector 4

Case 1: Solution for the North					
5	351,09	122,04	73,48	52,52	40,85
10	626,18	217,67	131,06	93,67	72,85
15	841,72	292,59	176,17	125,91	97,93
20	1010,61	351,29	211,52	151,17	117,58
25	1142,93	397,29	239,21	170,96	132,97
Case 2: Solution for the South when demand pattern in the South equals that of the North					
5	117,03	40,68	24,49	17,51	13,62
10	208,73	72,56	43,69	31,22	24,28
15	280,57	97,53	58,72	41,97	32,64
20	336,87	117,1	70,51	50,39	39,19
25	380,98	132,43	79,74	56,99	44,32
Case 3: Solution for the South when demand pattern in the South is lagged on that of the North					
5	22,40	7,81	4,71	3,37	2,62
10	39,50	13,93	8,40	6,01	4,68
15	53,70	18,73	11,30	8,08	6,29
20	64,48	22,49	13,56	9,70	7,55
25	72,92	25,43	15,34	10,97	8,54

Suppose that the patent system is used in the North but not in the South. Assume that the four widgets as a share of total expenditure on widgets are consumed in the same proportions (10, 20, 60, 10) in the two regions. In this case Table 4.2a indicates that the North will innovate the product as long as for the combination of (τ, T) the value in the table equals to or exceeds unity. The north will then consume the 4-th widget at the monopoly price p_4 which exceeds its marginal cost. Since there is no patent protection in the south the commodity will not be innovated in the south. The south will either not consume the product at all or it will imitate the product produced (invented) in the north. Abstracting from the cost of imitation we note that under competition the 4-th widget will be sold in the South at its marginal cost. The situation described above will not change at all if we further assume that widgets in the South are demanded in the proportions (20, 60, 18, 2) whereas the North demands them in the proportions (10, 20, 60, 10).

The introduction of the patent system in the South does not necessarily lead to a better resource allocation. Suppose that the patent length in the North is 20 years. The 4-th widget will then be innovated in the North as long as the elasticity of substitution τ is less than 8. On the other hand assume that the patent length introduced in the South is 5 years. Then the product will not be innovated in the south for all possible values of the elasticity of substitution τ under consideration and for the pattern of demand considered. The North will consume the 4-th widget at the monopoly price over the 20 year patent length. The South could choose not consume the product at all or it could consume it over the 5 year period at the monopoly price determined for the South, which may be different from that determined for the North. After the expiration of the patent in the South the 4-th widget could be sold in the South at its marginal cost.

Table 4.7: Welfare Effects of the TRIPs Agreement

	Elasticity of Substitution				
	2	**4**	**6**	**8**	**10**
NORTH					
Annual Income Transfer from South to North	17,2	7,4	4,7	3,5	2,8
Income of the North before the Transfer	60079,0	60034,1	60021,8	60016,0	60012,7
Gain as a percent of Income	0,029	0,012	0,008	0,006	0,005
SOUTH					
PV of Welfare Loss in the South	219,8	76,4	46,0	32,9	25,6
PV of Income Transfer from South to North	214,3	92,5	59,1	43,4	34,3
Present Value of Total Loss	434,1	168,9	105,1	76,3	59,9
Annuitized Value of Total Loss	34,8	13,6	8,4	6,1	4,8
Income of the South before the Transfer	20026,3	20011,4	20007,3	20005,3	20004,2
Annual Loss as a percent of Income	0,174	0,068	0,042	0,031	0,024

The introduction of the TRIPs Agreement, which extends patent life in the South from 5 to 20 years has according to Panagariya (1999) two main effects. First it extends the monopoly distortion in the south on all products innovated from 5 to 20 years. The resulting inefficiency lowers the welfare of South. In addition, the extension of the patent transfers a part of Southern consumers' income to Northern innovators through higher product prices. This redistribution further lowers the income in the South and raises that in the North. Secondly, the extension of the Northern stringent patent regime to the South will have beneficial effects on product innovation in the South. Table 4.7 shows that the welfare effect of the TRIPs Agreement changing the patent life from 5 to 20 years in the South depends on the elasticity of substitution τ, and that it increases with decreases in the value of the elasticity of substitution τ. The beneficial effects of the extension of the Northern patent regime to the South is obtained by considering the case when the South consumes the 4-th widget at monopoly price versus the case when the South does not consume[96] the commodity at all.

[96] In this case, it is assumed that imitation is not possible or profitable.

CHAPTER 5

TECHNOLOGICAL LAG AND PATENT LENGTH

The chapter five, considering the relationships between technological lag, patent duration and monopoly markups within a North-South framework, shows that for newly developed products the technological (demand) lag between North and South increases as the patent length is raised in South or reduced in North. Moreover, even when North and South agree upon the same terms of protection, the reduction in the global patent length shortens the technology lag between the two regions.

The analysis of patent protection continues to be of a considerable interest to academicians as well as to policy makers. In a seminal paper Diwan and Rodrik (1991) analyse the welfare effect of the strength of patent protection within a North-South framework where the two regions have different needs and tastes. They show that due to the scarcity of R&D resources which are assumed to be owned entirely by the North, a reduction in patent protection by the South lowers incentives to conduct R&D, giving rise to the production of technologies demanded by the South. Taylor (1993) emphasizes that the reduction of Southern protection may induce the North to employ other barriers such as masking or copy-protecting in order to prevent imitation, and shows that such costly efforts can raise the monopoly markups and reduce Southern welfare. If Southern firms try to unpackage the technologies masked by their Northern rivals, the efforts on masking and the costs of packaging rise even further. Competition between imitators and inventors raises both imitation and production costs leading to a fall in aggregate world welfare. Under those circumstances the North and the South can both gain from an multilateral agreements on Intellectual Property Rights (IPRs).

Besides the studies mentioned above which support the argument that it is to the benefit of both North and South to protect IPRs, Deardorff (1992) and Helpman (1993) maintain the opposite view. Deardorff (1992) shows that when the protection is extended from the country where innovation takes place to the country where the innovated product is only consumed, the welfare of the inventing country rises while the welfare of the other country may fall leading to a decrease in the world welfare. Thus, he proposed that at least the very poor countries should be exempted from protecting the innovations of rich countries.[97] Helpman (1993) examines patent protection within a dynamic general equilibrium framework, and shows that the South does not benefit from strong patent protection. He further points out that even the North may have some incentives to relax IPRs if the imitation rates in the South are sufficiently low.

In this chapter we consider a model of IPRs protection within a North-South framework. We focus on the impacts of the regional and global patent length upon the technological lag between North and South. We assume that all innovations take place in the North. The newly developed technologies are patented for certain time periods in both regions, and during the life of the patent the right to produce the patented technologies is warranted only to the Northern innovator. However, after the patents expire, these technologies are produced competitively in both regions. Owing to the regional differences in economic development and income levels, the distribution of consumers in the South over the technology space is assumed to be a scaled and lagged version of that in the North.[98]

We show that optimal monopoly markup is higher in the North than in the South. However, markups in both regions are decreasing in the patent duration. For newly developed products the technological lag between North and South increases as the

[97] This proposition of Deardorff is indeed in accordance with Part VI of the TRIPs Agreement, namely, 'Transitional Arrangements' which entitles least developed countries to a ten-year delay from the implementation of TRIPs Agreement. The delay can be extended upon request.

[98] This assumption presupposes that the distribution of consumers over the possible preference relations is identical in both regions.

patent length is raised in South or reduced in North. It is striking that, even if North and South agree upon the same terms of protection, the change in the global patent length affects the technology lag between two regions. In particular, a reduction in the common patent duration gives rise to a shortening of the demand lag between North and South.

The organization of the chapter is as follows: Section 5.1 introduces the model, which partially borrows from Diwan and Rodrik (1991). Section 5.2 derives the optimal monopoly markups and analyzes the effects of a change in the regional patent duration and the regional economic development level on optimal markups and technology lag by assuming constant but not necessarily equal patent lengths in both regions.

5.1 Model

Consider a North-South (N-S) framework in which all innovations take place in the North.[99] We assume that the potential technologies (products) are characterized by an infinite spectrum, indexed by $\theta \in (-\infty,+\infty)$. The range of available products are restricted to a continuous interval $[\theta^{l},\theta^{h}]$, where $\theta^{l} < \theta^{h}$. We assume that the set $[\theta^{l},\theta^{*})$ represents the products which were discovered in the past and are presently competitively produced. On the other hand, $[\theta^{*},\theta^{h}]$ is the set of products which are currently (at time $t = 0$) developed and ready to be marketed in both regions by a Northern innovator. The Northern firm is allowed to patent each newly developed product in the set $[\theta^{*},\theta^{h}]$ for a time period of T_i in the region $i = N, S$.

We allow no infringement for patents in world markets. We assume that the products whose patents expired are competitively produced both in the North and in the South. The cost of production incurred by the Northern firm is given by

$$C_N(\theta) = c_N\theta, \text{ for all } \theta \in [\theta^{l},\theta^{h}]. \tag{1}$$

---

[99] This assumption, also used by Diwan and Rodrik (1991), Deardorff (1992) and Helpman (1993), is not too restrictive, since by assumption, the North has stronger R&D background than the South.

The price $p_i(\theta)$ of the product θ in the region i is denoted by $p_i(\theta)$. Products in the interval $[\theta^l, \theta^*)$, where no patent is effective, are competitively produced and priced at the marginal cost level in each region i, whereas products in the interval $[\theta^*, \theta^h]$ are priced monopolistically by the Northern firm, due to the effective patent protection in the region i. For all patented products let $m_i(\theta)$ be the markup charged by the Northern firm in the region $i = N, S$, that is $m_i(\theta) = p_i(\theta) - c_N$ for all θ in $[\theta^*, \theta^h]$.

Distribution of consumers in region i is represented by a continuous (almost everywhere) and single-peaked function $f_i(\theta)$, defined over the interval $(-\infty, +\infty)$:

$$f_i(\theta) = I_i \bar{f}(\theta + \sigma_m m_i(\theta) z(\theta) + \sigma_T T_i z(\theta) - \sigma_e e_i), \tag{2}$$

where $\sigma_m, \sigma_e, \sigma_T > 0$ are positive constants and $z(\theta)$ is an indicator function given by

$$z(\theta) = \begin{cases} 1 & \text{if } \theta \in [\theta^*, \theta^h], \\ 0 & \text{otherwise.} \end{cases} \tag{3}$$

Here, I_i denotes the consumers' total income[100] and e_i denotes the level of economic development in region i. We assume that North is economically more developed than the South owing to historical, cultural and geographical conditions so that $e_N > e_S$. Moreover, $\bar{f}$ is such that $f_i''(.) < 0$ and $f_i'''(.) < 0$ for all i = N, S and $\theta \in (\theta^l, \theta^h)$.

Distributions $f_N(\theta)$ and $f_S(\theta)$ may be interpreted as the total demand for the technology level θ in the North and the South respectively. A given distribution function over the technology space denotes the optimal choices of consumers given their income levels, the product prices, the patent duration and the economic development level of the home region. We assume that $f_N(.)$ and $f_S(.)$ have single peaks, which lie over the region $(-\infty, \theta_i^*)$, i.e.

$$\theta_i^* > \arg\max_\theta f_i(\theta) \qquad i = N, S.$$

That is, the most preferred technologies in the North and South are not protected. Figure 5.1 plots the distributions of consumers in the North and the South. Note that $f_N(.)$ and $f_S(.)$ are discontinuous at points θ^* and θ^h where the product price is discontinuous.

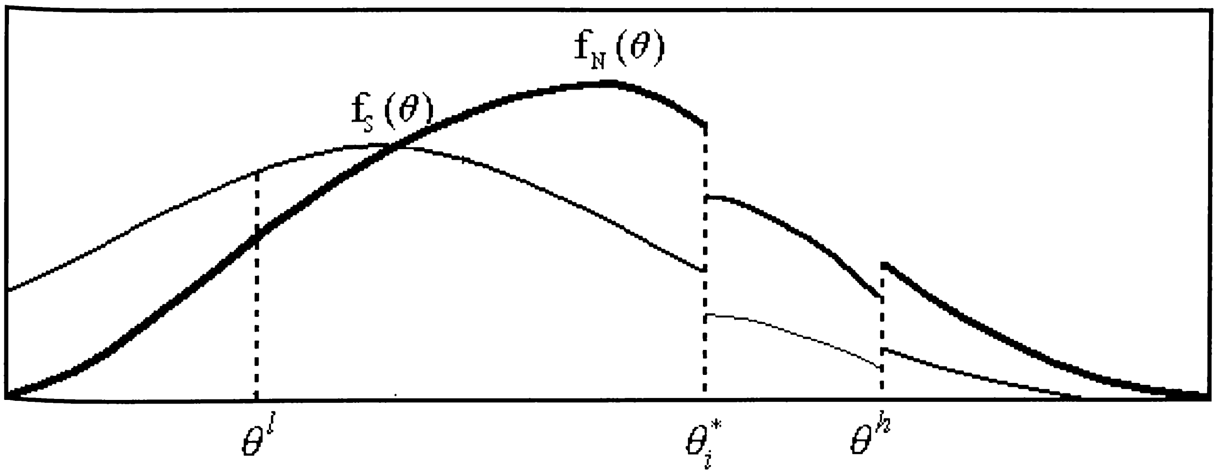

Figure 5.1. Consumers' distributions in the North and the South

From equation (2), it follows that a difference in distributions of Northern and Southern consumers may arise due to regional differences in (i) the prices of products, (ii) the patent length, (iii) the economic development level and (iv) consumers' income. It is clear from (2) that $f_S(\theta)$ is a scaled (by γ) and lagged (nonuniformly by $L(\theta)$) version of $f_N(.)$:

$$f_S(\theta) = \gamma f_N(\theta + L(\theta)) \tag{4}$$

where

$$\gamma = \frac{I_S}{I_N} \text{ and} \tag{5}$$

[100] It is implicitly assumed that consumers in both regions have homothetic preferences. Thus the Engel curves associated with consumers' demand are linear.

$$L(\theta) = \sigma_m (m_S(\theta) - m_N(\theta))z(\theta) + \sigma_T (T_S - T_N)z(\theta) - \sigma_e (e_S - e_N). \tag{6}$$

The parameter γ measures the relative market share of the South with respect to the North, and from (2), it equals the ratio of aggregate income of Southern consumers to that of Northern consumers. The variable $L(\theta)$ denotes the technological lag between the South and the North for the technology level θ.

5.2 Technological lag, monopoly markup and patent duration

We assume that for each newly developed technology there exists a unique Northern patentee (inventor), who runs the patents for the whole period in both regions. Total profits of the Northern inventor is then given by[101]

$$\pi = \sum_{i=N,S} \sum_{t=1}^{T_i} \int_{\theta^*}^{\theta^h} \pi_i(\theta) d\theta, \tag{7}$$

where

$$\pi_i(\theta) = m_i(\theta) f_i(\theta) \tag{8}$$

for all i.

The problem of the Northern innovator is to choose markups, in each region, over the interval $[\theta^*, \theta^h]$ so as to maximize her profits.

Proposition 1. *Optimal monopoly markup $m_i^*(\theta)$ in region $i = N, S$ is given by:*

$$m_i^*(\theta) = -\frac{f_i(\theta)}{\sigma_m f_i'(\theta)} \tag{9}$$

Proof: Differentiating (8) with respect to m_i, $i = N, S$, we obtain

[101] For simplicity, it is assumed that the intertemporal rate of substitution (discount rate) is zero. Since the patent duration is not a choice variable, the annual fee of maintaining patents in both regions is normalized to zero.

$$\frac{d\pi_i(\theta)}{dm_i(\theta)} = f_i(\theta) + m_i(\theta)\sigma_m f_i^{'}(\theta),$$

which vanishes at the optimal markup m_i^*. The second order condition

$$\frac{d^2\pi_i(\theta)}{dm_i(\theta)^2} = T_i\left[2\sigma_m f_i^{'}(\theta) + \sigma_m^2 m_i(\theta) f_i^{''}(\theta)\right] < 0$$

is satisfied at $m_i = m_i^*$ since $f_i^{''}(.) < 0$ for all $i = N, S$, and moreover $f_i^{'}(.) < 0$ due to the assumption that $\theta^* > \arg\max_\theta f_i(\theta)$. So, markups given by (9) maximize the monopoly profits. Q.E.D.

Corollary 1. *Optimal monopoly markup in the region* $i = N, S$ *is (i) decreasing in* θ*, (ii) decreasing in* T_i*, and (iii) increasing in* e_i *if* $\theta^* > \arg\max_\theta f_i(\theta)$ *holds ex-post.*

Proof. To show that (i) holds, we differentiate (9) to obtain

$$\frac{dm_i^*}{d\theta} = -\frac{1}{\sigma_m}\frac{\mathrm{d}[f_i(\theta)/f_i^{'}(\theta)]}{d\theta},$$

$$= -\frac{1}{\sigma_m}\frac{[(f_i^{'})^2 - f_i f_i^{''}]}{(f_i^{'})^2}(1 + \sigma_m m_i^*(\theta)),$$

$$= -\frac{1}{\sigma_m}\frac{H_i}{1+H_i},$$

where $H_i = [(f_i^{'})^2 - f_i f_i^{''}]/(f_i^{'})^2$. We note that $H_i > 0$, by the assumption that $f_i^{''}(.) < 0$. Therefore $m_i^{*'}(\theta) < 0$, i.e. optimal monopoly markups are decreasing in the technology level.

To show (ii), we calculate

$$\frac{\partial m_i^*(\theta)}{\partial T_i} = -\frac{1}{\sigma_m}\frac{d[f_i(\theta)/f_i'(\theta)]}{dT_i},$$

$$= -\frac{1}{\sigma_m}\frac{[(f_i')^2 - f_i f_i'']}{(f_i')^2}\left(\sigma_T + \sigma_m \frac{\partial m_i^*(\theta)}{\partial T_i}\right),$$

$$= -\frac{\sigma_T}{\sigma_m}\frac{H_i}{1+H_i} < 0.$$

Hence (ii) also holds.

Finally to show that (iii) is satisfied, we differentiate (9) with respect to e_i to obtain:

$$\frac{\partial m_i^*(\theta)}{\partial e_i} = -\frac{1}{\sigma_m}\frac{d[f_i(\theta)/f_i'(\theta)]}{de_i},$$

$$= -\frac{1}{\sigma_m}\frac{[(f_i')^2 - f_i f_i'']}{(f_i')^2}\left(-\sigma_e + \sigma_m \frac{\partial m_i^*(\theta)}{\partial e_i}\right),$$

$$= \frac{\sigma_e}{\sigma_m}\frac{H_i}{1+H_i} > 0.$$

So (iii) also holds, and thus Corollary 1 is satisfied.

Q.E.D.

Part (ii) of the Corollary 1 shows that an inverse relationship exists between the optimal markup level and patent duration. If the patent duration in a region is increased, consumers' distribution there shifts to the left. Then the demand for all patented technologies in that region decreases, giving rise to a fall in the optimal monopoly prices of the patented products.[102]

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[102] The inverse relationship between the monopoly markups and the patent duration was also demonstrated by Gilbert and Shapiro (1990). They show that, when providing rewards to innovators, there is a tradeoff between patent length (duration) and breadth which they define as the flow rate of profit.

Last part of Corollary 1 implies that the monopoly markups in a region increases as the region achieves economic development. The distribution of consumers in a region shifts to the right as the region develops, bringing about an increase in the demand for the protected technologies, and hence an increase in the optimal monopoly markups.

Corollary 2. *Optimal monopoly markups are higher in the North than in the South, i.e.,* $m_N^*(\theta) > m_S^*(\theta)$, *for all* $\theta \in [\theta^*, \theta^h]$.

Proof. Directly follows from part (iii) of Corollary 1 along with that the North is economically more developed than the South, that is, $e_N > e_S$. Q.E.D.

It is optimal for the Northern monopoly to follow price discrimination in world markets. Since the demand for the high-tech products under protection is lower in the South than in the North, it is optimal to charge a relatively lower markup for the patented products in the South. Figure 5.2 plots the optimal monopoly markups in both regions.

Corollary 3. *Profits of Northern monopolists obtained from the sales in region i is increasing in the wealth level* e_i, *if* $\theta^* > \arg\max_\theta f_i(\theta)$ *holds ex-post.*

Proof. Differentiating (8) with respect to e_i, in the range (θ^*, θ^h), we obtain

$$\frac{\partial \pi_i(\theta)}{\partial e_i} = f_i(\theta)\frac{\partial m_i^*(\theta)}{\partial e_i} + m_i^*(\theta)\frac{df_i(\theta)}{de_i},$$

$$= (f_i(\theta) + m_i^*(\theta)\sigma_m f_i^{'}(\theta))\frac{\partial m_i^*(\theta)}{\partial e_i} - m_i^*(\theta)\sigma_e f_i^{'}(\theta),$$

$$= - m_i^*(\theta)\sigma_e f_i^{'}(\theta) > 0, \quad i = N, S$$

for all i, since $f_i(\theta) + m_i^*(\theta)\sigma_m f_i^{'}(\theta) = 0$ by (9), and $f_i^{'}(\theta) < 0$ when $\theta > \arg\max_\theta f_i(\theta)$. So, π_i is increasing in e_i, and therefore profits obtained from region i is increasing in e_i.

Q.E.D.

We see that given the optimal monopoly markups, the technological lag given by (6) is not uniform over the product space. The lag between the demands by Southern and Northern consumers is constant for all nondeveloped and nonprotected developed technologies and proportional to the regional difference in the economic development level. However, the lag for patented technologies depends on the level of technology as well, since markups and patent length which are two of the determinants of the lag are not constant over the patented technologies.

Proposition 2. *Assume $T_S \geq T_N$. Then, the technological lag $L(\theta)$ is nondecreasing in θ almost everywhere.*

Proof. Inserting $m_N^*(\theta)$ and $m_S^*(\theta)$ into (6) and differentiating $L(\theta)$ with respect to θ we obtain

$$\frac{dL(\theta)}{d\theta} = \begin{cases} \sigma_m \dfrac{d}{d\theta}\left[m_S^*(\theta) - m_N^*(\theta)\right] & \text{if } \theta \in \left[\theta^*, \theta^h\right] \\ 0 & \text{otherwise} \end{cases}$$

or

$$\frac{dL(\theta)}{d\theta} = \begin{cases} \left[1 + H_S(\theta)\right]^{-1} - \left[1 + H_N(\theta)\right]^{-1} & \text{if } \theta \in \left[\theta^*, \theta^h\right] \\ 0 & \text{otherwise} \end{cases}$$

where

$$\frac{1}{1 + H_i(\theta)} = \frac{\left(f_i^{'}\right)^2}{2\left(f_i^{'}\right)^2 - f_i f_i^{''}}, \quad i = N, S.$$

Total differentiation of the last equality gives

$$d\frac{1}{1 + H_i(\theta)} = \frac{-2 f_i f_i^{'} (f_i^{''})^2 + (f_i^{'})^3 f_i^{''} + f_i (f_i^{'})^2 f_i^{'''}}{\left[2(f_i^{'})^2 - f_i f_i^{''}\right]^2} (\sigma_m dm_i^*(\theta) + \sigma_T dT_i - \sigma_e de_i).$$

Inserting

$$dm_i^*(\theta) = -\frac{1}{\sigma_m} H_i(\sigma_m dm_i^*(\theta) + \sigma_T dT_i - \sigma_e de_i)$$

into the above equation and dividing by de_i we obtain

$$\frac{d}{de_i}[1 + H_i(\theta)] = -\frac{-2f_i f_i'(f_i'')^2 + (f_i')^3 f_i'' + f_i(f_i')^2 f_i'''}{[2(f_i')^2 - f_i f_i'']^2} \frac{\sigma_m}{H_i} \frac{dm_i(\theta)}{de_i} < 0,$$

since $dm_i^*(\theta)/de_i > 0$ by (iii) of Corollary 1 . Similarly,

$$\frac{d}{dT_i}\left(\frac{1}{1 + H_i(\theta)}\right) = -\frac{-2f_i f_i'(f_i'')^2 + (f_i')^3 f_i'' + f_i(f_i')^2 f_i'''}{[2(f_i')^2 - f_i f_i'']^2} \frac{\sigma_m}{H_i} \frac{dm_i(\theta)}{dT_i} > 0$$

since $dm_i^*(\theta)/dT_i > 0$ by (ii) of Corollary 1. Note that

$$\frac{1}{1 + H_S(\theta)} - \frac{1}{1 + H_N(\theta)} > 0,$$

since $e_S < e_N$ and $T_S \geq T_N$. So, $L'(\theta) \geq 0$ for almost all $\theta \in [\theta^l, \theta^h]$. Q.E.D.

As it is clear from Figure 5.3, technological lag is lower in the interval of patented technologies than in the interval of technologies whose patents expired or which are not developed yet. Moreover, the lag in the range of patented products is increasing in the technology level. It is interesting also to analyze the relationship between the patent duration and technological lag.

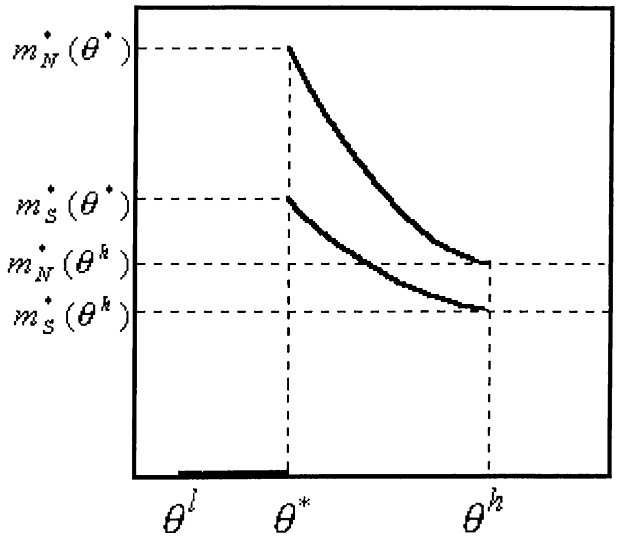

Figure 5.2. Optimal monopoly prices

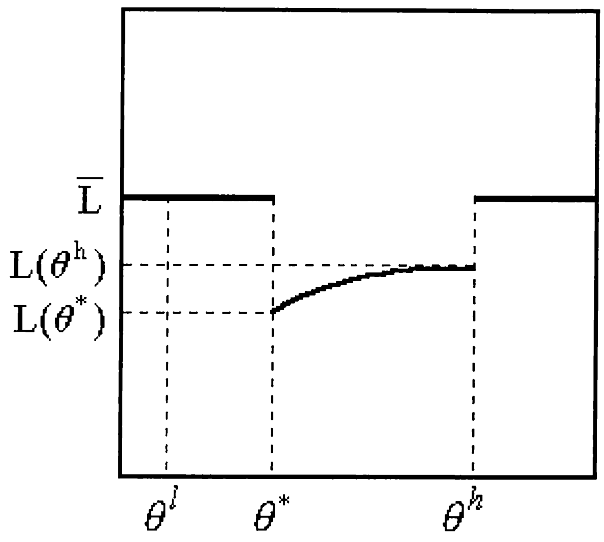

Figure 5.3. Technology lag

Proposition 3. *Technological lag $L(\theta)$ is nondecreasing in T_S and nonincreasing in T_N.*

Proof. Differentiating (6) with respect to T_N and T_S we obtain

$$\frac{\partial L(\theta)}{\partial T_N} = \begin{cases} -\sigma_m \partial m_N^*(\theta)/\partial T_N & \text{if } \theta \in [\theta^l, \theta^h] \\ 0 & \text{otherwise} \end{cases}$$

$$\frac{\partial L(\theta)}{\partial T_S} = \begin{cases} \sigma_m \partial m_S^*(\theta)/\partial T_S & \text{if } \theta \in [\theta^l, \theta^h] \\ 0 & \text{otherwise} \end{cases}$$

Along similar lines to those in the proof of Proposition 2 one obtains

$$\frac{\partial L(\theta)}{\partial T_N} = \begin{cases} -\sigma_T [1 + H_N(\theta)]^{-1} & \text{if } \theta \in [\theta^*, \theta^h] \\ 0 & \text{otherwise} \end{cases}$$

and

$$\frac{\partial L(\theta)}{\partial T_S} = \begin{cases} \sigma_T [1 + H_S(\theta)]^{-1} & \text{if } \theta \in [\theta^*, \theta^h] \\ 0 & \text{otherwise} \end{cases}$$

where

$$\frac{1}{1+H_i(\theta)}=\frac{(f_i')^2}{2(f_i')^2-f_if_i''},\ i=N,S.$$

It follows that $\partial L(\theta)/\partial T_N \leq 0$ and $\partial L(\theta)/\partial T_S \geq 0$, since $[1+H_i(\theta)]^{-1}>0$ for all i. Q.E.D.

The following proposition shows that if the patent duration is the same in both regions, then an increase in the patent duration raises the technological lag between the South and the North over all protected products.

Proposition 4. *Assume* $T_N = T_S = T$. *Then technological lag* $L(\theta)$ *is nondecreasing in* T *almost everywhere.*

Proof. Differentiating (6) with respect to T we obtain

$$\frac{\partial L(\theta)}{\partial T}=\begin{cases}\sigma_m \dfrac{\partial}{\partial T}\left[m_S^*(\theta)-m_N^*(\theta)\right] & \text{if } \theta\in\left[\theta^l,\theta^h\right]\\ 0 & \text{otherwise}\end{cases}$$

Mimicking the proof of Proposition 2, one obtains

$$\frac{\partial L(\theta)}{\partial T}=\begin{cases}\sigma_T\left([1+H_S(\theta)]^{-1}-[1+H_N(\theta)]^{-1}\right) & \text{if } \theta\in\left[\theta^*,\theta^h\right]\\ 0 & \text{otherwise}\end{cases}$$

where

$$\frac{1}{1+H_i(\theta)}=\frac{(f_i')^2}{2(f_i')^2-f_if_i''},\quad i=N,S.$$

Then, it follows that $[1+H_S(\theta)]^{-1}-[1+H_N(\theta)]^{-1}>0$ for all $\theta\in[-\infty,\infty]$, since $e_N > e_S$. Thus $\partial L(\theta)/\partial T \geq 0$. Q.E.D.

We note that optimal monopoly markups decrease in both regions with an increase in the global patent duration. Moreover, the induced fall in markups is higher in the North than in the South which leads to a decrease in the absolute value of the regional differences in markups and hence an increase in technology lag.

In this chapter we presented a simple model for the examination of the effect of patent length on technological lag between two regions. Among various findings, we have shown that technological lag is nondecreasing in global patent duration. This positive relationship implies relatively low levels of patent length if the international agreements on protection take into account the convergence of the consumption patterns, and hence of the welfares (utilities derived from consumption), among different parts of the globe.

One might worry that most of the results of this study depend upon the assumption that the distributions of consumers are single-peaked and that the lowest protected technology level is higher than the most demanded technology level in both regions, i.e., the demand of consumers of any region is decreasing in the technology level for the protected region. This assumption, which may seem to be restrictive, is nevertheless not too far away from reality as there is a delay between the rate of innovating new technologies and the absorption (adoption) of these technologies by the society.

CHAPTER 6

CONCLUSION

After studying the public good nature of knowledge within the general equilibrium theory, the thesis compares the patent protection system with alternative knowledge generating fostering systems, discusses the pros and cons of patent protection system, emphasizes the importance of knowledge for economic growth, and investigates the evolution of patent system over time to its ultimate version, the U.S. patent law. The thesis also evaluates the international trade dimension of intellectual property concept. In this context, importance of trade in intellectual property intensive commodities, diversification of patent stringency across countries and mutual patent grants in international knowledge flows are investigated. The findings indicate that, there is an increasing trend in trade of intellectual property intensive commodities, especially among the industrialized countries. Furthermore, it is reported that there exist large differences among the stringency of patent protection between developed and developing countries. Finally, findings indicate the existence of increasing number of international patent grants. Another contribution of the thesis is the analysis of patent protection within partial equilibrium, general equilibrium and North – South patent protection models. In all these models, three alternative policy choices are evaluated, namely government subsidy, patent protection and no protection case. The fourth contribution of the thesis is the construction of a North – South patent protection model, which deals with the possible effects of patent duration on technological differences between these poles. The model shows that for newly developed products, the technological lag between the North and the South increases as the patent duration is raised in the South or reduced in the North. The model also yields several results about optimum monopoly pricing conditions in the North and the South.

Chapter 2 investigates the importance of knowledge in both resource allocation and economic growth. As shown by Solow (1956, 1957), knowledge plays an important role in economic growth. Solow attributed 87.5 percent of the growth in the U.S. gross output per man-hour over 1909-49 period to technical change, hence knowledge. In line with Solow, Abramowitz (1956), Kendrick (1956) and Denison (1985) all emphasized the importance of knowledge. These studies revealed that knowledge is a critical factor in determining economic growth and that it must be generated and allocated efficiently in order to achieve positive per capita growth in the economy.

The Arrow-Debreu model of resource allocation shows that resources will be allocated efficiently in the economy, provided that the assumptions of convexity, universality of markets and absence of uncertainty are satisfied. These assumptions, together with the assumptions on private ownership, largeness, and the assumption that each economic unit has perfect knowledge on prices, preferences, production and consumption sets, assure the feasibility and also the efficiency of the competitive mechanism (Debreu (1959)). But the Arrow - Debreu model of general equilibrium abstracts from explicit consideration of knowledge and its generation. It assumes that knowledge is freely available to all economic units. However, knowledge today is no longer freely available. It is considered as one of the most critical factors in determining the competitiveness of firms and countries. Marketability of knowledge is also problematic, because of the non-rivalry and non-excludability characteristics of knowledge. These characteristics make knowledge a public good. Knowledge also violates the assumptions of convexity and absence of uncertainty. The chapter concludes that, competitive market system cannot achieve optimum allocation of resources including the production and dissemination of knowledge. Artificial alternative structures such as government financed R&D, academic institutions and patent systems have been developed. The chapter compares the advantages and disadvantages of each of these systems. The main problems are the emergence of monopoly power in the patent case and administrative difficulties, market distortions and moral hazard problems in the subsidy case. The chapter proposes that diversity in knowledge generation and allocation mechanisms enables good match with variety in characteristics, scales and contributions of innovative activities.

In addition to consideration of efficient allocation of resources including knowledge, the thesis investigates the roots of the relationship between scientific studies and industrial evolution. It is shown that these roots have a rather short history. Before the last part of the 19th century, there were almost no links between science and industrial technology. As emphasized by Rosenberg and Birdzell (1986), a close relationship between science and industrial technology started to form at the end of the 19th century. According to the authors, decentralization of the selection mechanism in innovation projects, existence of market forces to innovate, and the diversity and autonomy of research agencies, enabled U.S. to set up a fruitful link between science and industry.

As mentioned above, the main scope of this thesis is the patent system. In this framework, history of patent system is studied in order to shed light on the current patent system. As it is well known, legal systems, like the patent protection system, evolve incrementally through time. Analysis of the history of the patent system indicates that initially the scope of the patent system was much narrower than its present scope. The thesis also evaluates the U.S. patent law, which is considered as one of the most advanced patent regimes. Historical investigation of the patent system revealed that the system was constituted to induce the transfer of knowledge from developed countries to underdeveloped countries in the medieval times. Patent system was also used to keep inventions within inventor's country. Clearly, patent system did not aim to provide any private incentive for inventors to innovate. On the other hand, modern patent law is designed to foster inventive activites and information revealation within new inventions by providing exclusive rights to inventors. In this sense, it can be concluded that the patent system has changed continuously over time in order to fit the current needs.

Chapter 3 introduces the international trade dimension of intellectual property rights, especially that of the patent protection. The chapter defines the concept of intellectual property and presents its importance in international transactions. The analysis indicates that there is an increasing trend in the trade of intellectual property intensive commodities in total world trade. It is shown that major part of this trade is materialized within industrialized countries. The chapter also provides an economic overview of the TRIPs Agreement. This overview points that TRIPs Agreement, which specifies minimum standards, can be considered as the most advanced and effective international agreement in this field. TRIPs sets not only the standards of intellectual property rights protection but also its enforcement. Before the TRIPs Agreement, none of the previous international treaties or agreements could introduce any enforcement mechanism. The agreement imposes two important WTO principles in intellectual property protection framework, namely the most favoured nation and the national treatment principles. The first principle requires that member countries cannot discriminate between other member countries. The second principle establishes that each member country shall treat the nationals of other member countries, no less favorable than its treatment to its own nationals with respect to the protection of intellectual property. The chapter surveys the literature on TRIPs and concludes that intellectual property rights protection should be in harmony with competition rules in the country in order to minimize the possible adverse welfare effects of the TRIPs Agreement.

The economics of patent protection is analyzed using first the partial equilibrium and thereafter the general equilibrium framework in Chapter 4. Moreover a North – South patent protection model is constructed in order to evaluate the possible costs of TRIPs agreement to the South. In all these models, three alternative policy choices are evaluated, namely government subsidy, patent protection and no protection case. Chapter 4 also reveals that the South has a strong free riding incentive, whereas it is well known that northern high technology firms constantly invest on masking efforts to conceal knowledge within these new technologies. In this sense, a global consensus about intellectual property protection may be beneficial due to removal of these costly but not productive efforts.

The models in Chapter 4 give several important results about the patent protection for given parameters of the model. These parameters are degree of love for variety, market size (country size), demand pattern, extension of patent protection over differentiated goods market and patent duration. The main findings of this chapter can be summarized as follows:

- The degree of love for variety, which is represented by the elasticity of substitution in the model, is shown to be a critical parameter in the model. Both the monopoly profit and the welfare loss are sensitive to changes in degree of love for variety. Clearly, if degree of love for variety increases, which is equivalent to lower elasticity of substitution, then monopoly profit and welfare loss of society increase.
- Country size matters. Monopoly profits and welfare loss increase with increases in the country size. Thus larger markets create higher incentives to innovate.

- If patent protection is extended to other substitutes of the patented technology, then profits increase and welfare loss decreases. Thus, wider patent protection, which can be interpreted as an extensive patent scope, creates higher monopoly profit and lower welfare loss in the original sector.

- The model indicates that, if patent duration gets longer, then both monopoly profit and welfare loss increase.

- Hence, degree of love for variety, country size, and demand pattern are all important parameters in the model. But these parameters cannot be controlled directly by the governments. On the other hand, patent duration and the scope of patents (extension of patent protection over product space) can be precisely adjusted by legal authority. It is to be noted that patent duration and scope can be interpreted as a proxy for patent stringency. This interpretation implies that stronger patent protection regime creates higher monopoly profits for innovators and larger welfare loss for the society. These findings also suggest that, two policy variables, namely duration and scope, can be used to obtain an optimum solution. Clearly if market size, degree of love of variety, demand pattern and cost of R&D are given parameters, then the model may propose an optimum patent duration for this economy, which minimizes welfare loss and just recover R&D cost of innovators.

- The chapter enables to study the efficiency[103] of R&D laboratories. That is to say, the model implies that if R&D laboratory is more efficient in one country, then its innovators make higher profit per unit R&D cost, other things being equal. This result indicates that a country, which has more efficient R&D laboratories than its rival countries, makes more innovations than others, since more innovations are profitable to materialize in this country.

- The model also reveals that TRIPs agreement induces an income transfer from less developed countries to developed ones through stronger patent protection. Actually, this result sheds light on the resistance of developing countries in TRIPs negotiations.

[103] R&D cost is assumed to reflect efficiency of a laboratory.

- All these findings suggest that patent protection system is the second best policy at hand, since it fosters innovative activities but also generates welfare loss for society due to monopoly pricing in product markets. Patent system must be carefully designed in order to keep the economy working and innovating efficiently, while not creating too much monopoly distortions.

In the fifth chapter, a simple model is presented for the examination of the effect of patent length on technological lag between two regions. Among various findings, it is shown that technological lag is nondecreasing in global patent duration. This positive relationship implies relatively low levels of patent length, if the international agreements on patent protection take into account the convergence of the consumption patterns, and hence of the welfares (utilities derived from consumption), among different parts of the world. The main findings of this chapter can be summarized as follows:

- Optimal monopoly markup in a country is decreasing both in the level of technology and patent duration, while it is increasing in economic development level of country. This result can be interpreted as higher monopoly prices in developed countries than developing countries; furthermore, prices of technologies, which lie at the edge of technology frontier, are higher than prices of other technologies whose patent have expired.

- Monopoly profit also increases by the increase of economic development level of a country. For example, a northern innovative firm could make higher profits in its local market than less developed foreign markets.

- It is also shown that, technological lag is a non-decreasing function of the technology level concerning patented products. That is to say, technological lag between developed and developing countries is larger in higher technologies than primitive ones in patented products.

- The chapter suggests that, technological lag is non-decreasing in patent duration of developing countries, whereas non-increasing in patent duration of developed countries.

- The model shows that, technological lag is non-decreasing in patent length given that all countries share the same patent duration. This finding implies that, if TRIPs agreement induces longer patent duration, then technological lag between developed and developing poles would not be reduced.

As Professor Scherer indicated at the AEA Conference in 1996, there is an increasing trend in the number of studies on intellectual property. Actually, the subject is rather old, and goes back to medieval times. The inclusion of intellectual property into multilateral trade negotiations fosters these studies. Moreover, increasing communication capabilities, globalization, and increasing volume of international trade raises the infringement risks of intellectual properties. Especially, developed countries insist on higher standards which provide a minimum required non-discriminatory intellectual property protection. Most of the studies indicate that patent protection is the second best policy, since it distorts commodity markets through monopoly creation, while promoting inventions. However, detrimental parts of patent protection can be abraded by effectively coordinated public policies, specifically through the control of anti-competitive practices. Finally, knowledge disseminations ignore international borders. Moreover, today's technologies diffuse through digital environment without any limitation. All these increase the importance of efficient intellectual property protection regimes on a worldwide scale.

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