THE RELATIONSHIP BETWEEN PATENTS AND ECONOMIC GROWTH: A PANEL VAR AND CAUSALITY ANALYSES ON OECD COUNTRIES

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ABSTRACT

The patent subject requires a comprehensive analysis both theoretically and empirically as it is related to many concepts. Patenting is important not only for the patent owner, but also for society and the country. Over the years, the causes of economic growth have been put forward in various ways in different growth models. Sustainable economic growth can be achieved by the creation of innovation by industries that carry out R&D activities and the continuous feeding of innovation with R&D, according to R&D-based endogenous growth models. The innovation process is depicted as a cumulative one in which new innovations build on past achievements. Empirical evidence demonstrates that patents, as a form of intellectual property rights contribute to economic growth. Especially in knowledge-based new economies, patents play a essential role in the decisions of countries and companies to invest in innovation. This study first theoretically reviews the economic effects of patent and patent system. For this purpose, it explains the impact of patents on economic growth, starting from their role as an innovation indicator and considering the main benefits of the patent system. The study then empirically investigates the relationship between patents and economic growth for a panel of OECD countries between 1990 and 2019. By employing panel vector autoregression (VAR) approach and panel-VAR Granger causality analysis, the research distinguishes patents into patent applications and grants.

According to the findings of the Granger causality analysis, there is no two-way causality relationship between patents and economic growth, but there is a causality relationship from patents to economic growth. The findings from the empirical estimates confirm a significant contribution of patents to economic growth in OECD countries. The empirical results show that an improvement in patent grants play a decisive role rather than patent applications in enchancing gross domestic product.

Keywords: Patents, Innovation, Economic Growth, Panel VAR and Granger Causality Analysis

PATENTLER VE EKONOMİK BÜYÜME ARASINDAKİ İLİŞKİ: OECD ÜLKELERİ ÜZERİNE PANEL VAR VE NEDENSELLİK ANALİZLERİ

ÖZET

Patent konusu birçok kavram ile ilişki halinde olması sebebiyle hem teorik hem ampirik olarak kapsamlı bir analiz gerektirmektedir. Patent almak sadece patent sahibi için değil, aynı zamanda toplum ve ülke için de önemlidir. Yıllar içinde, ekonomik büyümenin nedenleri farklı büyüme modellerinde çeşitli şekillerde ortaya konmuştur. Ar-Ge temelli içsel büyüme modellerine göre sürdürülebilir ekonomik büyüme, Ar-Ge faaliyetleri gerçekleştiren endüstrilerin inovasyonu ortaya çıkarması ve inovasyonun Ar-Ge ile sürekli beslenmesi ile sağlanabilir. İnovasyon süreci, yeni inovasyonların geçmiş başarıların üzerine inşa edildiği kümülatif bir süreç olarak tasvir edilmektedir. Ampirik bulgular, fikri mülkiyet haklarının bir türü olan patentlerin ekonomik büyümeye katkıda bulunduğunu göstermektedir. Özellikle bilgiye dayalı yeni ekonomilerde, ülkelerin ve şirketlerin inovasyona yatırım yapma kararlarında patentler temel bir rol oynamaktadır. Bu çalışma öncelikle patent ve patent sisteminin ekonomik etkilerini teorik olarak incelemektedir. Bu amaçla, patentlerin ekonomik büyüme üzerindeki etkisi, bir inovasyon göstergesi olarak sahip oldukları rolden hareketle ve patent sisteminin temel faydaları göz önünde bulundurularak açıklanmaktadır. Çalışma daha sonra 1990 ve 2019 yılları arasında OECD ülkelerinden oluşan bir panel için patentler ve ekonomik büyüme arasındaki ilişkiyi ampirik olarak araştırmaktadır. Çalışma panel vektör otoregresyon (VAR) yaklaşımı ve panel-VAR Granger nedensellik analizini kullanarak patentleri patent başvuruları ve alınan patentler olarak ayırmaktadır.

Granger nedensellik analizi sonuçlarına göre, patentler ve ekonomik büyüme arasında çift yönlü nedensellik ilişkisi olmadığı, patentlerden ekonomik büyümeye doğru tek yönlü bir nedensellik ilişkisi olduğu belirlenmiştir. Ampirik tahminlerden elde edilen bulgular, OECD ülkelerinde patentlerin ekonomik büyümeye önemli bir katkı sağladığını doğrulamaktadır. Ampirik sonuçlar, gayri safi yurtiçi hasılayı artırmada patent başvurularından çok alınan patentlerin belirleyici bir rol oynadığını göstermektedir.

Anahtar Kelimeler: Patent, Yenilik, Ekonomik Büyüme, Panel VAR ve Granger Nedensellik Analizi

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ABBREVIATIONS

ARIPO: African Regional Intellectual Property Organization

ARDL: Autoregressive Distributed Lag Bound Test

FDI: Foreign Direct Investment

EAPO: Eurasian Patent Organization

EPC: European Patent Convention

EPO: European Patent Office

EU: European Union

GATT: General Agreement on Tariffs and Trade

GCC: Patent Office of the Co-operation Council for the Arab States of the Gulf

GDP: Gross Domestic Product

GMM: Generalized Method of Moments

GNI: Gross National Income

GNP: Gross National Product

ICT: The Information and Communication Technologies

IP: Intellectual Property

IPC: International Classification of Patents

IRF: Impulse Response Funtions

IPRs: Intellectual Property Rights

JPO: Japan Patent Office

KEI: Knowledge Economy Index

KI: Knowledge Index

KIPO: Korean Intellectual Property Office

MMSC: Model and Moment Selection

NAFTA: The North American Free Trade Agreement

OAPI: African Intellectual Property Organization

OECD: Organisation for Economic Co-operation and Development

OLS: Ordinary Least Squares

PCT: Patent Cooperation Treaty

PVAR: Panel Vector Autoregressive

R&D: Research & Development

SIPO: China's State Intellectual Property Office

SME’s: Small and Medium-Sized Enterprises

TRIPs: Trade Related Intellectual Property Rights

UNCTAD: United Nations Conference on Trade and Development

UNDP: United Nations Development Programme

USA: United States of America

USD: United States Dollars

U.S.: United States

USPTO: United States Patent and Trademark Office

VAR: Vector Autoregressive

WIPO: World Intellectual Property Organization

WTO: World Trade Organization

CHAPTER 1

1. INTRODUCTION

Economies are complex systems formed by the combination of many different actors. This complexity makes it interesting for research and understand the determinants of economic growth. Along with many prerequisites for economic growth, technology and innovation are a necessity for both companies and countries. The starting point of neo-classical growth theory is the empirical studies by Solow (1956) and Swan (1956). In the model defined by Solow, the main factors determining growth are the change in technology and the rate of population growth. However, these two factors are determined exogenously by the model. On the other hand, the endogenous growth theories accepted technology as an endogenous variable and dealt with it comprehensively. In the neo-classical growth model, expressed as the second wave in growth theories, technology was expressed as a residual of growth that could not be explained by labor and capital inputs. In this model, it is emphasized that economic growth depends on technological progress. In the endogenous growth models, which developed under the leadership of P. M. Romer in the 1980s and expressed as the third wave in growth theories, it is argued that research and development (R&D) activities and the innovations that emerged as a result of these activities constitute the source of economic growth. Aghion and Howitt (1992), propose a growth model based on where growth is determined as being increasing function of the size of technological progress and qualified labor force in addition to the research productivity, while being a function of the time preference rate of the individuals. At Schumpeterian growth models, although the role of international trade and especially the exports of high technological goods play a crucial role in economic prosperity, such goods necessitate investments that encourage R&D. While the factors as an example the natural resources, human capital, political and economic stability, educational status, high technology, density of R&D activities, etc. lead to differences in development and growth among countries, the most important factor is the innovation on which production is based.

There are many factors that affect economic growth. Today, the most important of these factors has been technological development and innovation. Organisation for Economic Co-operation and Development (OECD) (2013) emphasizes that long-term economic growth may exist with an economic environment that encourage innovation and the implementation of new technologies. Innovative activities support economic productivity and growth. Innovation is considered as a factor that ensures long-term productivity and economic growth. Accordingly, countries, which create and innovate new technologies, are growing faster than those who do not (Knowledge Networks and Markets, 2013). The study by Porter and Stern (2000) is one of the first to use aggregate patent data to examine the determinants and effects of innovation. They found that innovation was positively correlated with human capital and national knowledge stocks in R&D sectors (Porter & Stern, 2000). Patents, a form of intellectual property (IP) and the focus of this article, are one of the most widely used measures of innovation output.

Today, it is commonly accepted that innovative activities form the basis of economic growth. Countries that innovate, create new technologies, and encourage the adoption of these new technologies are growing faster than non-producers. Patents are seen as both cause and effect for innovation. In addition to importance of patents, they serve as common legal tools for promoting and disseminating innovation. A patent gives the inventor the right, for a limited time, to prevent others from economically using the innovation. Patents and patent system have been attracting the interest of economics for a long time. Patents are critically important to research and development-intensive sectors of national economies because patents increase competition in such industries. Investments play a key role in institutionalizing innovation and producing IP. Therefore governments try to create an enabling environment that encourages investment in IP and innovation. In addition to increasing productivity and profitability, intellectual properties and patents have a monetary value as intangible assets that contribute to a company's balance sheet and increase corporate value. In the last twenty years, intellectual property rights (IPRs) have moved up the policy agenda of many countries. Significant changes have occurred in the patent system throughout the world. With the rise of knowledge economy, technology and knowledge accumulation have become important factors for economic growth and development. Since the first laws to protect inventions were created in the 15th century, the patent system has evolved to encourage innovation and therefore economic growth. Many countries give more importance to patents resulting from innovation activities. Because it is believed that patents move countries to a better position regarding economic growth and development.

The main purpose of this thesis is to investigate the relationship between the number of patent applications, patent granted and economic growth in OECD countries and to reveal the direction and size of this relationship. For this reason, two hypotheses have been formed in the study. It has been tried to analyze empirically, theoretically, and quantitatively whether patents affect economic growth or whether economic growth is a result of patents utilizing panel VAR methodology. First of all, after the theoretical background, the relationship between R&D expenditures, patent data is provided and economic growth has been put forward theoretically by summarizing the studies in the literature. Then, the relationship between the patent and economic growth of OECD countries for the period 1990-2019 is analyzed employing Panel Vector Autoregressive (PVAR) and panel-VAR Granger causality anaylses.

The remainder of this study is organized as follows: In the second chapter of the study, the concept of economic growth is discussed with its sources and growth models. Then, general information about innovation, innovation indicators, innovation-patent relationship is provided. After that, the subject of patent is explained in detail as theoratical background, patent rights and system and patents agreements. The third section concentrates on the relationship between patents and economic growth and in OECD by presenting various statistics on the topic. The ultimate aim of this study is to empirically examine the interconnection between patents and economic growth in OECD economies by distinguishing patents into patents applications and patent grants, as presented in the fourth chapter. The thesis concludes by discussing the effects of the findings on the economic growth of countries.

CHAPTER 2

2. ECONOMIC GROWTH, INNOVATION AND PATENTS

Economic growth, innovation and patents chapter of the thesis consists of three main titles. First, economic growth concept, which leads to patent formation, economic growth sources and economic growth models are explained. Then, the concept of innovation and its fundemental determinants are discussed, since patents are considered as innovation output within literature. Finally, the main subject of the thesis are elaborated with respect to the framework of patents, patent right, patent types, patent system and patent aggrements.

2.1 Economic Growth: Theoretical Background

Economic growth has become the most important agenda topic in the field of economy, especially after the Industrial Revolution. First of all, the definition of economic growth and its basic concepts are explained in order to explain the theoretical background of economic growth, Then, how to measure economic growth are revealed. The growth has been tried to be analyzed by economists in a way of defining the factors which are affecting the growth and used in economic growth models. Therefore, economic growth models are discussed historically with their most important hypotheses at the end.

Economic growth is one of the main macroeconomic goals of all countries and is considered as the key to raise the living standards of people in a country (Ünsal, Makro İktisat, 2009). There are various definitions for the concept of economic growth in the literature. Simon Kuznets, in his classic book “Modern Economic Growth”, defines economic growth as follows:

We identify the economic growth of nations as a sustained increase in per capita or per worker product, most often accompanied by an increase in population and usually by sweeping structural changes. In modern times these were changes in the industrial structure within which product was turned out and resources employed-away from agriculture toward nonagricultural activities, the process of industrialization; in the distribution of population between the countryside and the cities, the process of urbanization; in the relative economic position of groups within the nation distinguished by employment status, attachment to various industries, level of per capita income, and the like; in the distribution of product by use-among household consumption, capital formation, and the government consumption, and within each of these major categories by further subdivisions; in the allocation of product by its origin within the nation's boundaries and elsewhere; and so on (Kuznets, 1966, pp. 35-38).

According to Peterson (1994:480), economic growth is defined "as a continuous increase in per capita production in society", as Simon Kuznets states. The increase in production depends on the level of technology of the economy, the quantity and quality of its resources (Peterson, 1994). The increase in the amount of goods and services produced in a country over time is called as economic growth. Economic growth means a continuous increase in real gross national product[1] (GNP) over time (Ünsal, Makro İktisat, 2009). Economic growth is the numerically measurable real increase in a country's production capacity or real gross domestic product (GDP), usually within a year[2] (AÖF, 2013). The GDP is the monetary values of all goods and services produced in a nation during a given time period, usually one year. GDP is more often used for comparison of a nation's economic progress against that of other countries (Brezina, 2011). Real GDP provides the opportunity to measure the change in physical production between periods by evaluating the goods and services produced in different periods at the same prices (AÖF, 2013).

GDP is important because it gives information about the size of the economy and how economy performs. The growth rate of real GDP is often used as an indicator of the overall health of the economy. That is, an increase in real GDP is interpreted as a sign that the economy is improving. It is seen that GNP was used instead of GDP until 1991 in the calculations of national income to measure economic growth. Although the difference between the two concepts is only the geography they cover, GDP has been accepted as the main measure of the production power of the economy recently (Gordon, 2000). The broadest measure of aggregate economic activity, as well

[1] GNP reflects the output of domestically owned enterprises, both within and beyond national borders.

[2] Real increase is the rate of increase after the effect of price changes is eliminated.

as the best-known and most often used, is gross domestic product (Abel, Bernanke, & Croushore, 2021). Even though both GDP and GNP serve as valuable indicators to present aggregate output in an economy, economists mostly discuss a nation's economic health and progress using GDP (Brezina, 2011). Measuring the change in real GDP or real GDP per capita throughout time expresses the economic growth rate in economies.

The United Nations Human Development Report's (UNDP) annual report evaluate the progress around the world, through an index that tracks advances in literacy, life expectancy and income. In the 1996 edition of the report, more detailed analysis on economic growth was carried on. It warns with this "policy-makers are often mesmerized by the quantity of growth" phrase and stated that "they need to be more concerned with its structure and quality." Five growth types have been identified as to be avoided within the report regarding the negative consequences of economic growth. These are jobless recovery or growth, ruthless growth, voiceless growth, rootless growth, and futureless growth (UNDP, 1996). Good growth, which is the opposite of the five types of negative growth described in the report and which recognizes human development as the primary goal, can be defined as follows (Erdinç, 2013): "Growth in which individual can freely make own decisions, income distribution is fair, human capital is given importance in addition to physical capital, qualities that will protect the future of human development are achieved, social solidarity and harmony are ensured, and employment is encouraged."

2.1.1 Basic Determinants of Economic Growth

Industrial development has an impact on increases in per capita incomes globally. As a result, many researchers have started conducting scientific studies to investigate the sources of economic growth. Income level differences among countries have increased the interest about the studies to figure out the source of growth.

Economic performance of a nation depends on many factors. Numerous studies have addressed these factors affecting economic growth. There are four basic variables that explain economic growth. These are; land, labor, capital and entrepreneurship. The determinants of economic growth can be also stated as natural resources, human resources, capital stock, technology, institutions, and economic choices made by citizens (Abel, Bernanke, & Croushore, 2021). Given straight forward assumptions on how the factors of production evolve over time, the steady-state level of output per capita can be expressed as a function of the propensity to accumulate physical capital, the population growth rate, the level and growth rates of technological and economic efficiency, and the rate of depreciation of capital (Boldrin & Levine, 2013). The production function expresses the physical relations between the factors of production involved in the production of a given good and the quantity of production. If labor (L), capital (C), natural resources (N), production technology (T) are used in the production of good A, the production function is formulated as follows (Dinler, 2022):

$$Q = f(L, C, N, T) \qquad \textbf{(2.1)}$$

Where Q is the amount of physical output, and C, L, and N are the amounts of physical inputs used in production in this formula. All kinds of tangible and intangible economic values that contribute positively to the production are accepted as capital (Svendsen & Jens Fyhn Lykke, 2007). Physical capital is divided into three basic groups. These are tangible capital, including physical, natural and economic; intangible capital, including social, organizational, cultural and the human capital that lies between the two. All the tools, equipment, machinery, and buildings necessary for the country's production activities are physical capital (Samuelson & William, 1989). Physical capital both increases labor productivity and provides direct services. Whatever the transition mechanism from capital accumulation to growth, the significant differences in the investment rate across countries and over time show that it a possible source of cross-country differences in output per capita (Bassanini & Scarpetta, 2001).

Human capital is the knowledge and skills that individuals acquire to increase their value in the labor market. In addition to being an extension of neo-classical growth theory, human capital is also shown as the main source of economic growth in various endogenous growth models (Petrakos, Arvanitidis, & Pavleas, 2007). The contribution of human capital to economic growth is realized through the increase in the productivity of employees as a result of the emphasis placed on education. Education facilitates the acquisition of new knowledge and skills that yields an increase production. The increase in production is the source of new technologies, new business areas, and eventually economic growth, respectively (Saxton, 2000). There are two main channels of interaction between human capital and growth (Ranis, 2011). The first channel that explains the relevant interaction from growth to human capital is based on technological change, public and household expenditures. The second channel, from human capital to growth, operates through domestic and foreign savings, where technology plays an important role. If the adoption of new technologies is aided by a highly skilled workforce, investments in human capital may have a more lasting effect on the growth process (Bassanini & Scarpetta, 2001). Benhabib and Spiegel (1994) stated in their study that human capital increases the capacity of the country by making technological innovations and thus has a direct effect on productivity. They argued that a country's adaptation of technology from foreign countries depends on the level of human capital in the country. Thus, they drew attention to the fact that the rate of a technologically backward country catching up with the leading countries depends on the level of human capital in its own country. This study and the similar ones in the literature emphasize that technology transfer in a country is not sufficient for technological development without human capital. Technology transfer can only be effectively utilized and spread through human capital, which is an indicator of the level of general skill and education available in the country (Keller, 2004, p. 774). Variables such as capital accumulation and labor force, which are considered to be effective in the economic growth process in traditional theories, are insufficient to explain economic growth today (Eser & Ekiz Gökmen, 2009).

Natural resources consist of the sum of non-renewable (oil, natural gas and mineral resources) and renewable resources (solar, wind, hydroelectric etc.) including underground riches and cultivated areas, pastures, free and forest areas (Ekins, Simon, Deutch, & Groot, 2003). All the useful elements that man finds ready in nature during production or that nature offers him for production (Dinler, 2022). The richness of natural resources creates an accelerating effect on economic growth for countries that show the ability to utilize these resources.

Currently, there are many acknowledgements that entrepreneurship serves as the main driving factor of economic growth. Entrepreneurship can influence the economy of a country in various ways. The important role of entrepreneurship is to build employment, productivity, innovation, competitiveness, and a source of income. According to the entrepreneurial theory developed by Schumpeter (1934), the contribution of entrepreneurs to economic growth depends on their tendency to innovate. In this sense, the entrepreneur seeks to create new profit opportunities while undertaking innovation activities. Entrepreneurial activities accelerate the creation, dissemination, and application of new ideas. It also leads to the emergence of new industries, creates competitive pressure, increases productivity, and, as a result, accelerates economic growth (Özkul & Dulupçu, 2007). Thus, well-planned and well-coordinated actions of entrepreneurs in a country can bring about a high economic growth rate.

As another factor that contributes to economic growth, technology can be defined as a systematic set of knowledge about how something is produced, consumed, or used (Bayraktutan & Bıdırdı, 2016). Systematic R&D activities and the dissemination of knowledge, the formation of technological capabilities through learning by doing and using, and the adaptation of innovations developed by other countries to production processes are the factors that lead to technological development (Dosi, 1998). Measuring the contribution of technological innovation to economic growth is not as easy as other factors. It is mostly represented by R&D, as it is not possible to measure technological development or knowledge as a determinant of long-term growth (Bassanini & Scarpetta, 2001). As a result of R&D, a new product may emerge, as well as the opportunity to manufacture existing products at a lower cost. In industrialized countries, technological development is seen as the most important determinant of economic growth in the long run since technological development leads to productivity gains (Nelson & Phelps, 1966). As Robert M. Solow emphasized in the 1950s, the main driving forces of sustainable economic growth are physical capital accumulation and technological development (Jones, 2001). R&D expenditures can be considered as an investment in knowledge that translates into new technologies as well as more efficient ways of using existing resources of physical and human capital. In particular, the potential benefits from new ideas may not be fully appropriated by the innovators themselves due to spillover effects, which imply that without policy intervention the private sector would likely engage unless R&D than what could be socially optimal (Bassanini & Scarpetta, 2001).

Apart from the basic determinants, foreign direct investment (FDI), which refers to the establishment of a new company in foreign countries, the acquisition of an existing company, or a capital increase, is also among the factors affecting economic growth. These investments bring along production technology and contribute positively to the economic growth of the invested country. For this reason, FDI is seen as one of the sources of economic growth.

Geography, demographic structure, education, public expenditures and infrastructure investments, privatization, institutional and political structure, exchange rate regime, and openness to foreign trade are other factors affecting economic growth.

2.1.2 Economic Growth Models

Different theories have been put forward on the factors that ensure economic growth and the stages through which economic growth will emerge. The place of innovation and patent concept in the historical process and economic growth models is tried to be revealed in this section. Increasing the production capacity of a country and raising its potential national income level is the subject of growth theories. The classical, modern and neo-classical growth models are briefly mentioned, and then the historical development and basic assumptions of the new endogenous growth models are explained. The impact of economic growth on patents and the contribution of patents to economic growth are explained in the third section.

After the Middle Ages, there has been significant changes in the economic field in the world. Mercantalism, which emerged between 1450 and 1750, is a system of thought that argues that precious metals constitute the real wealth of the state (Dinler, 2022). Mercantilists argued that the expansion of domestic markets, the abolition of intercity taxes and the free movement of goods would increase exports. Population growth will also reduce costs. Thus, they argued that industrialization would develop and contribute to the economic growth (Ekelund & Hebert, 1990).

The Physiocrat economic growth model, which emerged in the 18th century, is a model that argues that the growth of the country's economy is a spontaneous event (Ekelund & Hebert, 1990). They envisioned that the state should not intervene in the economy at all. Vincent de Gourney (1712-1759) first expressed these thoughts of the physiocrats with the phrase "*let do and let pass, the world goes on by itself* [3]" (Dinler, 2022). They believe that the source of growth was agriculture, the only productive sector that increases the country's income. They argued that exports stimulate agriculture, thus increasing producers' income and generating macro-level growth. For this reason, they encouraged the use of technology and scientific research to accelerate growth in agriculture (Özgüven, 1988).

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[3] Laissez faire et laissez passer, le monde va de lui meme

2.1.2.1 Classical Growth Models

The emergence of economic theories dates back to the ages before the Ancient Greeks. However, the foundations of today's economic thought were laid by classical economists (Dinler, 2022). It is accepted in the literature that classical economic thought began with Adam Smith's "The Wealth of Nations" published in 1776. The basic factors of production in classical economic theory are defined as labor, physical capital, natural resources and entrepreneur (Karagül, 2003). Additionally, the concepts of individuality, entrepreneurship and innovation are also dealt with in classical economic theory. The basic assumptions of classical economics are as follows (Hiç, 1994): Labor is considered as the single factor of production and is homogeneous. Capital is regarded as labor accumulated and embodied in the form of means of production, and natural resources as a gift from God. Therefore, the price of a good is explained by the labor theory of value. The economy is characterized by perfect competition and full employment. Thomas Malthus' law of population applies. The wage paid to labor is fixed at the minimum physiologically necessary level in the long run. The economy go into recession sooner or later.

Classical economists have listed the conditions necessary for growth as follows: Social and cultural environment, political management, favorable conditions for technical innovations, the adequacy and breadth of the market, the existence of a market economy (Kazgan, 1990). As a result of these factors providing economic growth, they believe that the intervention of the state in the economy would not be necessary. Classical economists believe that the full and efficient utilization of resources, one of the main economic problems, could be solved by free competition in the economy. Therefore, the prominent problem for classical economics has been economic growth (Tanyeri, 2000).

The first economist to examine the concept of economic growth is Adam Smith, who is considered the father of economics. The growth model developed by Adam Smith in “The Wealth of Nations” is built on the concept of *division of labor* [4] (Smith A. , 2003). In an economy that produces for export, when technological progress is achieved based on an organizational division of labor, the productivity of labor will

[4] For Smith division of labor is the chief source of productivity gains. In his famous pin factory example, if each man sppecializes in some aspect of pin making, it tenders possible a dramatic increase in total output and output per man (Chandra, 2004).

increase. In this case, there will be an increase in output in the economy and thus it will bring an enrichment in the economic structure of the country. In the first case, due to the high profit rates in the economy, capital accumulation will increase and the increased capital accumulation will bring an increase in labor demand. As output increases over time, the demand for labor increases and therefore the wage rate increases. This situation has a positive effect on the desire of labor to work. Therefore, the population begins to increase. This process continues until the country reaches its maximum wealth. After the country reaches its maximum wealth, capital accumulation slows down, profit rates decrease and wages begin to fall. When profit rates fall to the level of interest rates, economic stagnation begins (Ünsal, 2007). In “The Wealth of Nations”, Smith explain the concept of the *invisible hand* that the overall economy will work well if there are free markets and individuals conduct their economic affairs in their own best-interests (Abel, Bernanke, & Croushore, 2021). The factors that Smith interprets as economic growth are of political origin. He attributes economic prosperity to the annual product of labor and the number of those who consume it (Hunt, 2009). According to Adam Smith, the technological progress caused by the division of labor (which increases the productivity of labor) is primarily the result of the creativity of the workers in the workshops. Adam Smith analyzes economic growth based on the assumption that capital accumulation is low compared to natural resources. He adopts innovation as both the cause and the consequence of capital accumulation for economic growth.

David Ricardo explains his opinion about growth in his “Principles of Political Economy and Taxation”, published in 1817. The basis of Ricardo's economic analysis is the division of total production between wages, rents and profits. Ricardo is one of the economists who emphasized that technological developments would be effective on growth. The basic assumptions of Ricardo's theory of economic growth are (Gürak, 2006): The law of diminishing returns applies in agriculture.[5] Perfect competition and full employment prevail in the economy. The state does not interfere in economic life. Technological innovations in industry are not sufficient for growth in the long run. According to David Ricardo, growth first occurs spontaneously and automatically,

[5] In the view of Thomas Robert Malthus (1776-1834), real national income increases when the amount of labor in the economy increases, all other factors being held constant. The increase in real national income is at a decreasing rate. Labor productivity decreases as the amount of labor increases.

then the economy goes into recession. He argued that an increase in labor demand would accelerate population growth, increase in production and thus ensure economic growth (Tezel, 1989). The common view used by Smith and Ricardo in their economic growth models is that while the law of increasing yields is valid in the labor factor, the law of decreasing yields is be valid in agriculture. Agricultural production first begins with the opening of the most fertile soil for production. When these lands are insufficient as a result of population growth, less fertile lands are started to be cultivated in order to feed the increasing population. When the production increases, workers wage does not change, but as a result of the increase in production, the rent absorbs the entire profit. This is the steady-state point at which profit becomes zero and there is no capital accumulation.

Another classical economist, Thomas Malthus, published one of the first and most influential books on population, "An Essay on the Principles of Population", in 1798, in which he included the Malthusian growth model. The importance of Malthus in the growth literature stems from his treatment of the relationship between economic growth and population growth rate. In Malthus' growth model, the causality relationship between income level and population growth is bi-directional. In the population theory, the biological reproductive capacity of humans progresses with a geometric increase (2,4,6,8…), while the increase in output progresses with an arithmetic increase (1,2,3,4…) (Henderson, 1992). High population ratios cause a decrease in per capita income due to decreasing marginal productivity (Yalman, 2010). As output per capita declines over time, growth will come to a standstill. Malthus' view of population is based on the assumption that the more likely people are to have nature, the more children they will have. Because Malthus believes that human behavior is guided by nature. Malthus states that if not brought under control, the population will increase more than food production and as a result insufficient provision of vital needs will be a major problem (Brezis & Warren, 2003). He states that technological innovations will have a positive effect on economic development, but this has a limit. Explaining the contribution of innovation over prices, it states that it will create a cost-reducing effect (Özceylan, 2006).

Karl Marx, the pioneer of Marxism, the source of socialist economic thought, is one of the economists who think that technology has developed industrial capitalism. In 1867, in "Das Kapital", Karl Marx introduced the Marxist model of capitalist growth, which includes the *labor theory of value* and *the theory of surplus-value*.

According to the labor theory of value, the value of a good is determined by the units of labor and time required to produce that good. According to Marx, labor determines the value of production and is a dynamo in the growth process (Acar, 2001). Marx argues that new inventions and technological developments such as steam engines, railway construction will bring success (Basalla, 2013). Marx’s law of technical change is the combination of progressive with regressive tendencies that is described. Profits, accumulation and employment can be stimulated only through its operation. The result is endogenous cycle of expansion and contraction, which takes the place of the steady running up or down of the classical mechanism. In this manner Marx’s general law of accumulation makes regular fluctuations an inherent property of economic growth (Lowe, 1954).

In the classical school, the concept of innovation is mostly considered within the scope of technological developments and the discussions on this issue continue in the growth models that emerged in the following years. Post Keynesian (Modern) growth model is based on a reinterpretation of J.M. Keynes' writings, particularly his article “The General Theory of Employment, Interest, and Money” published in 1936 (Fontana & Gerrard, 2004). These theories are referred to as the *Harrod-Domar model* in the literature because of the similarity of the independent contributions made by the British economist Roy F. Harrod (1939) and the American economist Evsey D. Domar (1946). While Domar researched the conditions that would enable the growth to be sustained based on the full employment equilibrium (Domar, 1946), Harrod investigated the conditions for the growth to reach the full employment equilibrium based on the underemployment equilibrium (Harrod, 1939). According to Domar's growth model, investment expenditures in an economy create two important effects: Capacity increasing effect and income increasing effect. In Harrod's growth model, the general level of prices does not change. There is a closed economy and there is no foreign trade. In a closed economy, income is divided between consumption and savings. In the economy, only one good is produced and there is no delay. Production is only a function of capital. The Harrod-Domar growth model can most clearly be measured by increases in national income. If the national income level is Y and the increase in national income is shown with ΔY, the growth rate (Y) is indicated by the expression $Y=\Delta Y/Y$. In the Harrod-Domar model, the inverse capital/output ratio is used instead of the productivity of capital. In this model, the actual growth rate achieved by the investment rate should be equal to the required growth rate to ensure sustainable and balanced growth (Alagöz, 2004).

The Harrod Domar model is the first model to address the growth systematically. Keynes make suggestions about the macro balance of the short-term economy and do not mention a subject such as long-term growth. In this respect, the Harrod-Domar model is a long-term macro-based Keynesian analysis. The capacity-enhancing effect, which Keynes ignored, is included in the model and Keynes' static views on growth were made dynamic in the Harrod-Domar model (Acar, 2001).

2.1.2.2 Neo-classical (Solow) Growth Model

Neo-classical growth theory, based on the pioneering work of Solow (1956), developed with the contributions of many economists[6] in the 1960s (Ehrlich, 1990). The neo-classical growth model is designed to show how the growth in capital stock, growth in the workforce and technological developments in an economy interact with each other and how they affect the economic growth of a country. Since technology is considered exogenous in this model, economic growth is supported by technological progress independent of economic forces.

Neo-classical growth theory emerged as a result of empirical studies in two separate articles by Solow and Swan, published in 1956 (Solow & Swan, 1956). In the growth theories put forward by Solow and Swan, it is emphasized that the most important factors affecting growth are labor, capital, and technology. Capital and labor are imperfectly substitutable. It is possible to present the Solow economic growth model as four variables: Income (Y), physical-material capital (K), labor (L) and knowledge or labor efficiency (A). The relationship between economic growth and technological development in neo-classical economic thought was first discussed by Solow (1957). In his study covering the years 1909-1949, Solow calculates that technical development contributed about four times more than capital accumulation to economic growth in the non-agricultural sector in the United States (US). He also argued that 87.5% of the increase in per capita production in this period was due to technological developments (Tiryakioğlu, 2011). The realisation that knowledge, broadly defined, plays an important role in economic growth was first discovered by

[6] E. F. Denison, D. Cass, T. C. Koopmans.

Robert Solow (Uppenberg, 2009). The basic assumptions of the neo-classical growth theory are as follows: In the model, returns to scale are constant. That is, the inputs increase at the same rate, and the output increases from there at the same rate. The economy is always at potential output and full employment. In the economy, a single homogeneous product is produced and consumed. This commodity also constitutes the GDP of that country. The marginal productivity of capital is decreasing. Savings and investments are equal. Technological changes are purely external. When technology is included in the model, it can produce results that increase economic growth. The convergence hypothesis is valid. The population grows at an exogenously determined rate. Since the law of diminishing returns works in the Solow growth model, the main determinants of growth are changes in technology and population growth rate (Solow R. , 1957).

Countries with the same steady-state characteristics at the beginning will have a lower per capita income than those with a higher population growth rate. Neo-classical growth theory postulates that technical progress is exogenous and proceeds at a steady rate. Solow states that the part of economic growth that cannot be explained by labor and capital inputs is due to technological progress in his study covering a period of approximately fifty years for the US economy (Solow & Swan, 1956). Because it is thought that technological development is also provide social development. According to Solow's modeling, technological development has a significant and positive effect on savings, capital and productivity in the long run. The model assumes that the long-term growth rates of developing and developed economies will converge, under the assumption that technology levels are exactly the same in all countries and do not change. This hypothesis is called the *convergence hypothesis*. In the long run, it means that the per capita income levels of the countries will converge, and therefore the development differences will disappear. A country that saves more will be richer than a country that saves less. If the saving rate is high, the economy will have a larger stock of capital and output at a steady state (Solow R. , 1957). According to the convergence hypothesis, which is a prediction of neo-classical theory, low-income economies grow faster than high-income economies and income differences between them decrease. At the same time, the growth rate of high-income economies slow down after a point (Umutlu, Yılmaz, & Günel, 2011). Solow emphasized that the unexplained part of economic growth other than the increase in labor force and capital is due to technological developments. This difference in growth is called the *Solow* *residual*. In this ecole, it is stated that "it is important to invest in innovation and therefore it is necessary to provide incentives to companies." The aim here is to be strong in the market and to be protected against competition, thanks to new products to be obtained through innovation or new production techniques (Aghion & Howitt, 1992).

Neo-classical growth theory has two conclusions. The first is that without technical progress, there will be no economic growth, and the second is that an increase in the savings rate have as much impact on growth as the shock situation (Parasız, 2003). Although there have been developments in neo-classical economic thought on innovation, the models have remained within a limited framework as technological developments are assumed to be exogenous variables.

2.1.2.3 Endogenous Growth Models

The neo-Schumpeterian growth model emerged as a reaction to the neo-classical growth model, which was very popular among growth theories until the 1980s. The Solow-Swan growth model and/or neo-classical growth models, which have failed to properly explain the growth process over time, have been replaced by endogenous growth models. The neo-classical growth model failed to theoretically explain the underlying drivers of growth. To address these shortcomings, a new growth theory, *endogenous growth theory*, has emerged (Uppenberg, 2009). Endogenous growth models foresees increasing returns to scale and sustaining ongoing growth above the stationary state growth rate. With the evolutionist theory, it has been accepted that the technological advances that occur as a result of R&D activities are intrinsic to economic growth. According to the endogenous growth models, which are accepted to have started with Romer (1986) and Lucas (1988), technological development will lead to increased returns on investments. Technological innovations that emerged as a result of the R&D studies of the units aiming at profit maximization in endogenous growth models constitute the source of economic growth (Özcan, B. & Arı, A., 2014).

The main determinants of endogenous growth theories are a process that provides and maintains growth from within, shaped by its own internal dynamics. These main determinants are the cultural, social and other characteristics of the country, as well as the education, health and technology policy. According to the model, R&D activities lead to the emergence of new products, which leads to the emergence of different production processes with effective production methods. Two basic and new views of economic growth are emphasized: The first is knowledge and the second is human capital (Parasız, 2003).

The most important assumptions of the endogenous growth model are as follows: Economic growth results from intra-economic factors. Technological development is an endogenous variable. Government intervention is needed to achieve the optimal growth rate.

According to Snowdon and Vane, there are three basic elements on which endogenous growth theories are based. The first one is technological developments, which are considered as the most important cause of economic growth; the second one is to accept existing and future technology as an internal variable. Third, once the idea is used, it does not require additional costs for subsequent use (Snowdon & Vane, 2005). R&D, globalization, digitalization and the importance given to human resources are the biggest differences between the old economy and the new economy (Yumuşak & Özgür, 2007). The concept of innovation is also seen as one of the most important factors in the new economy.

Kenneth Arrow stated that knowledge is constantly increasing with learning by doing and technological developments in the production process. Arrow (1962), one of the pioneers of the endogenous growth theories, noticed in his research that the costs of the companies decreased, the product quality increased and they developed new products over time due to the increasing experience in some sectors. It is argued that this process, defined as *learning by doing*, results not from R&D expenditures but from increased experiences (Arrow, 1962). As a result of learning by doing, companies will gain experience and produce technical knowledge in the production process at the same time. This knowledge provides a positive externality to other companies as well as the producing company, and the process of dissemination of knowledge is realized by using it by other companies. According to Hofer and Polt, the neo-classical theory of innovation started with the Arrow. Most of the technological changes take place within the firm. Employees show rational behavior. Therefore, the result of the learning process in production is already innovation (Hofer & Wolfgang, 1998). In neo-classical growth theories, it is stated that technology would affect economic growth, but as in the classical view, technology is considered external.

According to Philippe Aghion and Peter Howitt, the source of growth is *vertical technological innovation*[7] taking place in the R&D sector. It is possible to evaluate Aghion and Howitt's model within the framework of three basic features. The first is that technological innovations are formed through investments in the R&D sector under the imperfect competition market. Under this assumption, the inventor has a say in the market as a monopolistic power until the patent expires. Secondly, products that have expired disappear from the market and are replaced by new ones due to the destructive nature of technological innovations. Third, the technological structure is discontinuous (Aghion & Howitt, 1992). An entrepreneur who successfully innovates obtains a patent. Here, the assumption is made that patent rights continue indefinitely. Although the patent right lasts forever, the monopoly power remains until a new technological innovation is made. The model cannot predict when a technologically superior innovation will occur (Aghion, Haris, Howitt, & Vickers, 2001). In the model, there is a significant intertemporal spillover effect. A technological innovation increases productivity without losing its effect forever. Each innovation produces a creative effect aimed at obtaining monopoly profits. However, it also removes the rents from the previous innovation. Therefore, the increase in R&D activities causes a decrease in the profits obtained from these activities and the emergence of a patent competition (Aghion & Howitt, 2004).

Aghion and Howitt (1992; 1998) took a Schumpeterian approach to endogenous growth theory and developed a two-sector model. In the model consisting of production and research sectors, the production sector includes the production of final goods, while the research sector is for the development of intermediate goods used in the production of the final goods (Yıldırım, 2009). Thanks to the innovations emerging as a result of R&D activities, newer products are introduced to the market and old products become obsolete. At the end of this process, while the old ones disappear, they are replaced by better and new products, and the Schumpeterian creative destruction process works (Taban & Şengür, 2014).

Robert. J. Barro, in his study named “Determinants of Economic Growth: A Cross-Country Empirical Study” published in 1996, determined the main factors of economic growth as high level of human capital, level of GNP, productivity rate,

[7] In the Aghion-Howitt model, there are innovations produced as a result of R&D activities and these innovations show a successive improvement in product quality.

government expenditures, legal order, advantageous foreign trade terms, investment rates, regional variations are stated under eight headings (Barro, 1996). According to Barro, a good legal order, less corruption, low inflation-based government policies, longer life expectancy, low fertility rates, increase in primary and secondary education, and improvement in foreign trade balance contribute to the increase in real GDP per capita. Thus, a positive contribution to growth is made (Gürak, 2006). Barro tries to explain the effect of the progress in technology on growth with the investment of governments in innovation and education. According to Barro, increasing economic growth will only be possible by encouraging innovation. Therefore, according to endogenous growth models, R&D is the driving force of growth (Barro, 1990). The existence of sustainable growth in endogenous growth models includes certain conditions such as physical and human capital, level of public expenditures, export rate, population growth rate, openness, political stability and protection of patent rights (Grossman & Helpman, 1994).

2.1.2.3.1 Paul Michael Romer

Paul M. Romer's model, which is one of the pioneers of endogenous growth models, is built on R&D activities and innovations. According to Romer, the source of economic growth is knowledge. The contribution of knowledge to production is R&D activities that produce new designs and new technologies (Romer, 1990). The two basic views in Romer's work are as follows: Technological development is the essential dynamic of growth. Technological development encourages economic decision-makers to accumulate more capital. As a result, both increase output per labor force. It is the formation of technological development with the initiatives of economic decision units. The inherentness of technology also stems from these promoted initiatives.

According to Romer's model, R&D activities and growth increase as the market expands. Firms or countries operating in markets with a large stock of human capital show faster growth (Romer, 1990). Firms which develop new knowledge and products with their R&D activities set prices on the fixed cost of knowledge. Companies that want to maximize their profits go to monopolization by protecting the new knowledge and technologies they have acquired by investing in R&D with the help of mechanisms such as patents and property rights. New products and processes that emerge as a result of R&D activities will be used by other companies, resulting in a *spreading effect*. As a result, economic growth will occur (Taban & Şengür, 2014). In the *AK model* introduced by Romer (1986), firms face diminishing returns for investing in knowledge. Due to knowledge spillovers, the rate of return to knowledge at the economy level can be constant or increasing (Uppenberg, 2009).

The four basic inputs in this model are capital, labor, human capital, and an index of the level of the technology. The formal model of the economy has three sectors. The research sector uses human capital and the existing stock of knowledge to produce new knowledge. Specifically, it produces designs for new producer durables. An intermediate-goods sector uses the designs from the research sector together with forgone output to produce the large number of producer durables that are available for use in final goods production at any time. A final goods sector uses labor, human capital, and the set of producer durables that are available to produce final output. Output can be either consumed or saved as new capital (Romer, 1990).

When a firm produces a design, it can obtain an infinite life patent on that design. It leases these patented goods to final output companies. It is assumed that this company, which has the patent for the design in question, is the only company that produces it. The patent owner can obtain the same monopoly profit whether he produces the goods himself or gives licenses to others (Romer, 1990). In Romer's model, R&D firms acquire patent rights for their designs and then sell these patent rights to the intermediate goods sector. Since entry into the R&D sector is free, the profit of R&D firms is equal to zero. On the other hand, firms in the intermediate goods sector can make positive profits as their entry into this sector is restricted by monopoly power (Romer, 1990).

The basic function of Romer's model is shown as in equation (2.2):

$$Y = K^{\alpha} (AL_Y)^{1-\alpha} \qquad \textbf{(2.2)}$$

Where Y represents production, K capital stock, L_Y workforce ve A stock of creative ideas. With respect to K and L_Y, it will become a production function with a constant return but when we take a stock of creative ideas as an input to production. When we double the inputs, production will more than double (Ünsal, 2007).

One of the most important results of Romer's model is that a larger stock of human capital leads to higher economic growth (Romer, 1990). The use of qualified workforce resources such as scientists, researchers and technical personnel, who constitute human capital, in R&D activities ensures the development of new information and technologies. This ensures growth in the economy. Romer built his model on three pillars. First, technological development lies at the heart of economic growth. The second pillar, technological development, is driven by informed decisions made by firms stimulated by market incentives. The third and most important premise is that there are very important differences between the use of knowledge in production as a production factor and the use of other production factors.

Romer's work in 1990 adds a new dimension to economic growth theories. In this study, Romer discusses the importance of R&D in the economic growth and indirectly innovation process (Romer, 1990). In summary, Romer suggests that knowledge accumulation is the driving force behind economic growth. According to his theory, countries should encourage economic policies that include investments in new R&D and programs that develop human capital in order to sustain economic growth.

2.1.2.3.2 Robert Emerson Lucas

The growth model developed by Robert E. Lucas in 1988 argues that the source of long-term growth is human capital. Accordingly, countries with strong human capital will have higher economic growth than countries with weak human capital. Population dynamics are referred to as exogenous in the model. Lucas argues that the increase in the human capital of the individual not only increases his or her own productivity but also contributes to the productivity of other production factors (Lucas, 1988). A few important assumptions of the model are as follows: The economy is closed and operates in a perfectly competitive market. Economic decision units have rational expectations about future prices. The technology of the economy is constant returns to scale. The rate of technological development is exogenous.

The model derived from the Cobb-Douglas type production function by Lucas (1988) and including human capital is shown below (Lucas, 1988):

$$Y = AK^{\alpha}(vhL)^{i-\alpha} \quad \textbf{(2.3)}$$

Where Y is output, A is technology level, K is physical capital stock, v is the time period spent by households, h is the average skill level of employees, and L is labor. vhL shows the impact of human capital on production (Çoban, 2003).

Lucas considered human capital as one of the factors of production, like physical capital, and stated that in a situation where human capital grows unlimitedly, sustainable growth would be possible in the long run. He also emphasized that in reality, the increase in the human capital of the individual contributes to the productivity of all factors of production, apart from increasing his own productivity. The increase in human capital is realized through government investment in education and the development of technological infrastructure. It is also emphasized that the positive impact of these investments on human capital accumulation will affect growth more than the impact of investments in physical capital (Kibritçioğlu, 1998).

2.1.2.3.3 Gene Michael Grossman and Elhanan Helpman

In the "Dynamic Comparative Advantage" model where innovation is internalized, by G. M. Grossman and E. Helpman, technological development as a tool of knowledge capital is stated as an important element. According to the model, R&D has two main purposes: Reducing the production cost and producing new products. The Grossman and Helpman model, like the Aghion and Howitt model, explains that industrial innovations are the engine of economic growth and long-term economic growth depends on R&D investments. Countries that allocate more resources to R&D investments have more technological innovation and experience faster growth.

While the R&D sector produces technology, innovation is a by-product of knowledge capital. In the model, research activities increase the stock of knowledge. The link between innovations and knowledge capital is established by the patent system, which is a specific property right. Patents cannot occur if the dissemination of technology and knowledge are prevented and companies protect their inventions through secrecy. On the other hand, if knowledge and technology spread freely, the compellingness of the patent system with international regulations comes to the fore. Inventors are protected by making a profit, and international transmission of knowledge is ensured. Thus, the patent system both encourages innovation and accelerates growth at the world level (Rivera-Batiz & Xie, 1992).

Technological development is seen as the driving force of growth and as a result three important features emerge. The first is the importance of allocating resources for the creation of new knowledge. Secondly, the profit motive drives the investments made in R&D activities of this resource. Third, the dissemination of knowledge is critical to sustaining growth (Grossman & Helpman, 1990a) (Grossman & Helpman, 1990b).

Less developed countries, which cannot allocate sufficient resources for R&D investments, provide the needed technologies in two ways such as increasing their openness ratios and transferring technology from developed countries. However, technology transfer does not occur spontaneously. To make it happen, the technology transfer incentives of less developed countries and the facilities they provide to multinational companies play important roles (Grossman & Helpman, 1991). The assumptions of the Grossman and Helpman model are as follows: The potential for the development of new goods is unlimited, and the resources required for innovation are fixed. There are no diminishing returns to scale in the knowledge production sector. Wage rates are determined by the free entry condition. Goods are priced as a function of wage rates. The number of firms operating in the market is determined by their profit expectations. In the case of static equilibrium, prices and resource allocation are analyzed under the assumption that the quantity of product varieties and the value of firms are constant (Arnold, 2005).

2.1.2.3.4 Joseph Alois Schumpeter

Joseph A. Schumpeter comes to the mind as first economist, when the concept of innovation is mentioned. In his work "Theory of Economic Development" in 1912, he made an important contribution to the inclusion of the concept of innovation and entrepreneurship in economic theory. Schumpeter claims that innovation is changes to be made in a production process, in the mode of production. Thanks to innovations, there is an increase in output quality or quantity (Schumpeter, 1934). Schumpeter (1983) states that innovation consists of activities that involve the emergence of a new product or a new production method, opening up to a new market, acquiring a new source of supply or the emergence of any new forms of industrial organization (Schumpeter, 1983).

Schumpeter developed an economic approach, which states that the leading actor of development is not an inventor, but an innovator (İçke, 2014, pp. 19-20). According to Schumpeter, while inventions emerge as a result of an intellectual effort, the desire of the business person transforms the invention into innovation. Innovation does not have to be a scientific study, doing things differently is explained by the term innovation (Dolanay, 2009, p. 175).

The Schumpeterian growth model is based on three main ideas (Aghion, Akcigit, & Howitt, 2015): Long run growth results from innovations. Innovations result from entrepreneurial investments that are themselves motivated by the prospects of monopoly rents. New innovations replace old technologies. In other words, growth involves creative destruction. Joseph Schumpeter states that "innovation is a tool which determines the competitiveness of firms with his analysis called *creative destruction*." The cause of creative destruction is technological innovation. The concept of technological innovation is not only used as the use of a new technique in the production process; at the same time, Schumpeter defines it as a concept based on four basic views: "Producing a new good, opening new markets, going to new market organizations and finding new raw material sources (Schumpeter, 2003)." Schumpeter defines innovation as the elimination of the old. This definition reveals creation and destruction (Schumpeter, 2012). In the process of creative destruction, it is expressed that companies, which are old, inefficient and cannot follow the technological development are withdrawn from the market. When entrepreneurs introduce innovations in any field, they gain a monopoly right over this innovation and profit from it. The profitability situation continues until another innovation is introduced in this field or a similar product is introduced by the entrepreneurs. Over the time, the product will begin to be standard and the profits of the old innovation will decrease or become zero. This emerging process is defined as creative destruction (Heilbro, 2003). On the other hand, the creation process refers to the stage in which companies that enable new, efficient technological development. In other words, innovation to be included in the market, emerge and economic growth is achieved.

Schumpeter explains economic growth through circular flow. According to the circular flow, the innovative activity of the entrepreneur leads to the deterioration of the current equilibrium state and this creates a new state of equilibrium. The transition of the economic system to a new equilibrium point occurs with small quantitative changes (Schumpeter, 2008). Schumpeterian creative destruction can also be defined as the disruption of the circular current. As a result, the process of creative destruction begins with the incorporation of new products, processes, inputs, organizations or markets into the economic system by the entrepreneur. When innovation is first included in the system, it provides monopoly profit to the entrepreneur. However when time passes, the monopoly profit turns into normal profit with the emerging imitators. When the profit advantage of innovations disappears, investments shift to another area and the sector shrinks until a new innovation emerges (McCraw, 2009). When a new innovation emerges, this process starts again and thus the process of creative destruction continues with the formation of discontinuous equilibrium points (Van Praag, 1999). The creative accumulation process means that large companies with advanced R&D structures incorporate innovation into the economic system through their professional research capabilities. Thus, these companies can maintain their current strength by changing within the creative accumulation process. Moreover, they can gain a competitive advantage (Landström, 2005).

Schumpeter concludes that more competition has not always positive impact on innovation. Some studies that have attempted to examine Schumpeter's conclusion have found that less competition increases the rate of return on R&D in firms. This study suggests that more competition may actually harm the innovation process (Blundell, Griffith, & Reenen, 1999).

The most important elements in the Schumpeter’s creative destruction model are the technological innovations that enable product or service development and the patent systems that protect innovation (Özer & Çiftçi, 2009).

2.2 Innovation and Patents

Nowadays, the transition to knowledge economies with the information age has made innovation activities inevitable for sustainable high growth and a welfare society. With the developing world and changing technology, the concept of innovation has come to the fore. Since the beginning of the 1900s, it has been an important part of the agenda of especially developed countries. For more than fifty years, very serious research and studies have been carried out on it.

The innovation process based on creative ideas, which forms the basis of economic development, is also considered the most important prerequisite for the patent creation process. Therefore, this section discusses, the concept of innovation, its types, importance and basic economic indicators.

2.2.1 Innovation: Conceptual Background

The word *novation* is a word that originated in the field of law in the 13th century. It was first used by researchers such as Machiavelli (1513) and Bacon (1625) to mean dedication to innovation for the productive power and creative abilities of individuals.

The concept of innovation has started to be used in social and economic fields as of the 20th century (Godin, 2008).

Innovation is derived from the Latin word "*innovatus* is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organization or external relations." Webster defines innovation as "a new and different result (Webster, 2003)." Innovation is defined as "a new or improved product, method or service that is marketable, introduced at the end of the transformation process" by European Commission in 1995. According to the world-renowned management scientist Peter F. Drucker, although innovation is a certain function of entrepreneurship, it is a tool of entrepreneurship and an action that provides resources that create a new capacity to create wealth. Also Drucker pointed out that a large firm that cannot innovate in an age that requires innovation is in danger of shrinking and disappearing (Drucker, 1998). According to Tushman (1986), innovation refers to the process of creating a new product, process or service (Tushman & Nadler, 1986). The concept is defined by Luecke as "the synthesis, combination or concretization of knowledge to create an original and new product, process or service" (Luecke, 2003). Schumpeter (2012) defined the concept of innovation for the first time in his book "Theory of Economic Development" with the following words:

> A new product is a qualitative improvement in an existing product or service. It is the development of new production methods and their application in production processes. Creation of new market areas. Finding new resources related to the procurement process. It is the creation of new organizational structures (Schumpeter, 2012, p. 66).

The concept of open innovation highlights the advantages of firms of using knowledge inputs and knowledge outputs to accelerate internal innovation and expand markets for external use of innovation (Chesbrough, 2003).

The disruptive innovation brought to the literature by Clayton Christiensen and it is based on the fact that the factors that play a role in the success of a firm are also the factors that can lead the firm to failure. The concept of disruptive innovation is used to explain the failure of large firms, especially when there are sharp changes in the market. The main purpose of disruptive innovation is not to produce the best-performing products and services, but to offer different and/or lower performance features together with a low-cost approach at the beginning (Christensen, Raynor, & McDonald, 2011).

The OECD/Eurostat 2018 edition of the Oslo Manual identifies two types of innovation for firms (OECD, 2020). Product innovation refers to “a new or improved good or service that differs significantly from the firm’s previous goods or services and that has been introduced on the market.” This includes significant improvements to one or more characteristics or performance specifications, such as quality, technical specifications, user friendliness or usability. Business process innovation refers to “a new or improved business process for one or more business functions that differs significantly from the firm’s previous business processes and that has been brought into use in the firm.” This includes the various functions within a firm, such as the production of goods or services, distribution and logistics, marketing and sales, information and communication systems, and administration and management.

Johnson (2001) suggested that innovation can occur in five different forms. Johnson defined the first form of innovation as any change in the range of products or services an organization brings to market. The second form of innovation is finding new uses for an existing product or service other than its original purpose. The third one is the introduction of a product or service into a different and new market other than the market it was originally intended to appeal to. Developing a product or service in a new way different from its original use or transportation design or delivering it to the consumer is introduced as the fourth innovation form. The fifth form of innovation is developing a new way of doing business, different from the way businesses have and adopted before (Johnson, 2001).

Innovation is at the heart of improvements in living standards and can affect individuals, institutions, entire economic sectors and countries in various ways. In order to establish an innovation-based sustainable economy in a country, there is a need for qualified and entrepreneurial manpower, and an environment that enables the generation and development of new ideas. At this point, governments have a facilitating and encouraging role. The growth of countries is directly proportional to the mechanisms that support innovation (Elçi, 2006).

Competition encourages innovation because, as the performance of the companies subject to competition can be compared, they are compelled to improve the cost and functionality of their products and services (Lazear & Rosen, 1981). Competition results in higher the demand elasticity for products; so that, an innovative company is rewarded by increased sales of its products and services, which in turn enables it to attract more investment and financing at lower cost than less successful companies (Baily, Gersbach, Scherer, & Lichtenberg, 1995). There are externalities in innovation because firms are unable fully to appropriate the gains from their own innovation. Technological spillovers reduce the cost of rival firms because of knowledge leaks, imperfect patenting, and movement of skilled labour to other firms (Mansfield, 1986).

The higher the number of innovating enterprises in a country, the higher the living conditions of the people in that country and the welfare of that country. Welfare and living standards in a country increase if competitiveness increases; for competitive power, it is necessary to increase productivity. The most important tool that increases productivity is innovation. Therefore, innovation is the key to economic growth for countries.

2.2.2 Determinants of Innovation and the Role of Intellectual Property Rights

Various views and measurement suggestions have been put forward by different authors for micro-scale innovation indicators. It is possible to summarize the main indicators of these indicators as follows: "R&D activities, number of patents, technological adaptation, skill level, patent expansion, new product presentations, trademarks, sales figures, trained workforce, quality certificates received, time to market, cost and performance improvements (Thamhain, 2003)."

Measuring innovation performance at the macro level requires a rather different and more challenging process than measuring a firm's innovation performance. Making country-level measurements and making comparisons between countries requires coordination on a global scale. Therefore, innovation performance measures at the macro level; are mostly carried out by large-scale global institutions such as the European Commission, Eurostat and OECD. The OECD, which is at the forefront of these organizations, makes measurements and evaluations at the country level according to the methods and criteria specified in the report named Oslo Manual (OECD/Eurostat, 2018). One of the indicators used to represent innovative performance is R&D expenditures. Another important innovation indicator is the number of patents. The protection brought by the patent system is important because it encourages businesses to develop new technologies. Other indicators that can give clues about the magnitude of innovative performance at the macro level are the number of researchers, the number of academic articles published in a year, scientific publications, and the number of researchers at universities (Karaöz & Albeni, 2004).

In the last two decades, IPRs have attracted greater interest on the policy agenda of countries. IPRs can be defined as “legal rights arising from creative activities in industrial, scientific, literate, and artistic fields.” IP is the embodiment of individual or corporate thoughts on a product. On the other hand, industrial property rights are the rights that enable inventions, innovations, and original designs in the fields of industry and agriculture to be registered in the name of their creators or to register signs that distinguish goods and services in the field of commerce on behalf of their creators. Industrial property rights authorize the right holders to make absolute and exclusive use for a certain period of time (Şehirali, 1998). IP-related activities often involve the preservation or use of knowledge generated through R&D, software development and engineering, design, and other creative works. IPRs include patents, utility patents, industrial designs, trademarks, copyrights, integrated circuit designs, plant breeders' rights (new plant varieties), geographical indications, and confidential information such as trade secrets (WIPO, 2004). Patent rights constitute an important part of industrial property rights. Significant changes have occurred in the patent system worldwide, with IPRs coming to the forefront of countries' policy agendas. Chen and Puttitanum conducted a study on 64 developing countries to analyze the impact of IPRs on innovation. It is concluded that IPRs have a positive impact on innovation. The findings of the study indicate that there is an u-shaped relationship[8] between IPRs and economic growth (Chen & Puttitanum, 2005). IP is recognized as a powerful tool for economic development and wealth creation for a country (İdris, 2002). IP protection is important for innovators to reap the fruits of their investment in innovation and maintain their competitive advantage. However, IP is not optimally utilized in all countries, particularly in developing countries. In this regard, the effective management of both innovation and IP should be a strategic goal that should be prioritized especially in knowledge-based and innovation-intensive economies.

In today's conditions, with digitalization, intangible assets are becoming increasingly important among the assets of businesses. Intangible assets on a

[8] An u-shaped relationship exists if the dependent variable first decreases with the independent variable at a decreasing rate to reach a minimum, after which dependent variable increases at an increasing rate as independent variable continues to rise.

company's balance sheet indicate the market value of the company. The OECD's report on "Intellectual Property as an Economic Asset" reveals that a large proportion of a company's market value is determined by its intangible assets. This report emphasizes the importance of the role of IP in business performance in knowledge-based economies (OECD, 2005). With the transition to a knowledge-based economy, intangible assets become important resources of businesses. R&D and patent data prove that intangible assets are important for modern economies. According to statistics published by WIPO, R&D expenditures of OECD countries amount to approximately 772 billion US dollars. Similarly, patent statistics show an increase in innovative activity around the world (WIPO, 2008).

Park (1999) investigated that the factors affecting the patenting decision abroad in its study for 16 source countries and 40 target countries between 1975 and 1990. The result of the study is that IPRs protection encourages more foreign patents. Thus, IPRs appears to have a strong positive effect on the patent decision (Park, 1999). Since innovation is a concept closely related to R&D and technological developments, there are many studies in the literature that examine the effects of innovation on economic growth. Although these studies, which take different variables or variable components as an innovation indicator, may reveal different views and results in the short run; almost all the studies that examine the effects of innovation on economic growth in the long run conclude that innovation positively affects economic growth and development (Wang, 2013). R&D is to increase the stock of knowledge within the systemic basis and to reveal new studies by using it (Guellec & Potterie, 2001). Allocating more resources to R&D activities lead to more innovation and more patent activities. It is also possible to perceive patents as a final product (output) of R&D activities. Theoretical studies in the literature focusing on the R&D patent relationship have concluded that the two variables are positively related to each other.

Nowadays, with the increasing use of technology, the innovation competence of countries is determined by the following indicators (Akın, 2001): The rate of R&D expenditures to GNP, the number of scientists and engineers working in the R&D sector, the number of patents, scientific publications, the number of people using computers, the internet, and communication tools. As a result of the concentration of R&D activities in a company, while the technological know-how in the company increases, the innovation capacity of the company increases over time (Audretsch, et al., 2002). When R&D expenditures increase, the production and export of high-technology products and services increase. The increase in high technology and exports positively affects economic growth. For this reason, R&D investments and R&D activities are the prerequisites for technological development. According to 2020 OECD data, the first four countries with the highest share of R&D expenditures in GDP respectively are Israel with 5.44%; South Korea with 4.81%; Sweden with 3.53% and the USA with 3.45%. As a result of the high share of resources allocated to R&D in real national income, advanced technology transfer protected by patents can be made.

R&D activities in a knowledge-based economy may hold a key to achieve a higher technological progress and living standards (Bilbao-Osorio & Rodríguez-Pose, 2004). R&D activities consist of processes involving the generation, development and use of new knowledge regarding the design of new products, new processes or new applications. Therefore, R&D activities are a driving force to promote technological progress and affect economic growth (Guellec & Potterie, 2000). According to the study by Bound et al. (1984)[9], innovative activities carried out outside of official R&D institutions may not be included in the R&D statistics. In this case, patenting will be a more reliable indicator of innovative activities compared to R&D (Dosi, Pavitt, & Soete, 1990).

Patents have long been recognized as a rich and potentially productive data source for innovation studies (Taşgit & Torun, 2016). Ensuring the dissemination of innovative knowledge is one of the purpose of the patent system. Based on this basic purpose, patents keep an important place in the dissemination of innovative knowledge (Rockett, 2010). Pavitt (1985) argued that patents reflect not only creative activities but also innovative activities (Pavitt, 1985). Patents grant the holder an exclusive rights for a limited time, increasing the incentive to innovate. However, exclusive rights allow firms to move to a monopoly position in the market. A monopoly position leads to high prices and an insufficient supply of final goods, causing market distortions and efficiency loss. To correct the potential inefficiencies of monopoly market power, the patent system, ensures that information is made public, thereby ensuring that society eventually takes full advantage of the activity of invention. Weak patent protection

[9] Patent and R&D data from 2582 American companies were used in the study, and it was determined that the companies engaged in R&D activities received patents.

may lead to inadequate investment in innovative activities. On the other hand, improperly strong patent protection may lead to excessive monopoly disruption.

Figure 2.1. summarizes the steps taken from a creative idea to a patent grant. As visualized in Figure 2.1, the first step in the patenting process is ideas. Creative ideas are a step that triggers R&D and therefore initiates the innovation process. It can said that the result of the innovation-oriented process is patents. “The use of the knowledge obtained as a result of R&D activities in the production of a new product or in order to provide efficiency in the existing production is called innovation (Case, Fair, & Oster, 2014).” Innovation is adopting and commercializing a new product, method or organizational structure by trying, developing or imitating it.

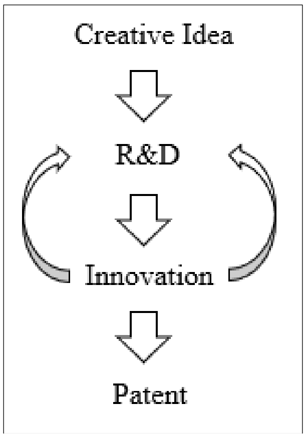


Figure 2. 1 Process from R&D to Patent
Source: İ. Kaya (2009). Ar-Ge’den Patente Uzanan Süreçte İstemlerin Önemi. Mühendis ve Makina, 50 (596), 20-22.

During knowledge creation, R&D activities, which are mostly measured by R&D expenditures, accumulated capital or the number of R&D personnel, are the main input elements in the development of new technological solutions that lead to innovation and in the search for new knowledge. For this reason, patents can be considered as an intermediate output of creative activity (Pakes & Griliches, 1984).

The concept of technology, which gained great importance after the Industrial Revolution, can be interpreted as production information in general terms. Technology transfer refers to the import of technology needed to increase productivity and contribute to economic growth and economic development from technology producing countries (Tiryakioğlu, 2006). The fact that a country is a part of the global innovation system is one of the conditions for technology transfer on a global scale. In this way, qualified foreign investment that will carry out innovation activities can be attracted to the country, companies can access global information and technology more easily. Researchers and research institutions become part of global information and technology networks. Patent, which means the protection of an innovation or invention in a country or region for a period determined by law, helps to trigger new studies on innovation by disseminating information at the micro and macro level (OECD, 2008). In the absence of a patent system in the country, the risk of imitation will be high and firms will not be willing to share their technological know-how. Hence, promoting national and international technology transfer by generating commercial property rights is seen as one of the important functions of the patent system. With the patent system, counterfeiting attempts will be effectively deterred while also increasing the expected returns from FDI and licensing, which will have a positive impact on technology transfer (WIPO, 2008). As a result of Smith's (1999) study on the US, he emphasizes that a weak IPR system is a barrier to exports. The reason for this export barrier is the threat of imitation the exporter's technology (Smith P. J., 1999). The main benefit of strong IPRs protection is the promotion of R&D, which leads to innovation and higher long-term growth (Falvey & Foster, 2006). To motivate innovation, governments try to get inventors to profit from invention. But it is also important to consider that protecting innovators too tightly can limit the spread of new ideas and therefore opportunities for economic growth.

Patent and know-how (trade secret) license agreements are important for effective technology transfer. Technology transfer can take place in different forms, such as through publications, joint R&D agreements, joint venture arrangements or FDI. For most developing countries, advanced technologies are expected to be transferred from developed economies. International technology transfer occurs through imports, FDI, licensing and patent applications by non-residents. Policies aimed at maintaining macroeconomic stability can facilitate countries' access to foreign technology by encouraging technology transfer (Falvey & Foster, 2006). According to Erdost (1982), technology can internationally transferred through many channels, namely; "agreements based on intellectual property (license, patent and know-how agreements), foreign capital investments, imports (machinery, vehicles, raw materials, etc.), information about patents, technical plans, projects, magazines and books such as extension tools, interaction between countries (travel, migration, congress, seminar, student and expert exchange, etc.), international cooperation (technical assistance programs and technical cooperation, etc.)" (Erdost, 1982).

Innovation is still discussed as a concept by economists. Conceptually, it is interpreted as one of the tools for economic growth, development and competitiveness. In terms of protecting and strengthening international competition, securing intellectual property rights and strengthening the patent system also increase the speed of innovation and economic growth.

2.3 Patents: Theoretical Background

This section provides a detailed conceptual framework on patents and the patent system, the historical development of the patent system and patent aggrements. To understand the role that patents play in the economy, the theoretical background on the nature and development of patents should be carefully examined. Patent data is one of the most important sources of technological knowledge. According to WIPO, which provides the most comprehensive data on patents, average more than one million patents applications have been filed each year since the 1980s. Globally, 1.5 million patents are granted per year (WIPO, 2020). A patent is a national industrial property right system that prevents the imitation of any invention[10] with commercial value (Prodan, 2005). Thus, the ultimate purpose of patents is to encourage invention and innovation (Plant, 1934).

2.3.1 Patent and Patent Rights

In the Cambridge dictionary, a patent is defined as "the official legal right to make or sell an invention for a particular number of years and to get the official legal right to make or sell an invention" (Cambridge Dictionary). Initially, the term *letters patent*, meaning an unsealed letter, was used to describe the privileges granted by the king in England. However, in the later stage such unsealed letters began to be issued only for new applications and inventions (Saran, 2019). Patent or in other words letters patent refers to an innovation that can be applied in the field of industry as a creative

[10] Inventions are technical solutions to existing problems in any branch of industry, including agriculture. In short, invention can also be defined as technical solutions to existing problems. In order to be able to talk about the invention, a problem and the solution of this problem are necessary. Inventions; It must be novel, creative and industrially applicable.

product of human thought (Yosmaoğlu, 1978). According to World Intellectual Property Organization (WIPO), “a patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem.” Patent expresses “the capture of a new technological development by researching and developing the existing technology” (TPE, 2010). In the words of the European Patent Office (EPO): “A patent is a legal title granting its holder the right to prevent third parties from commercially exploiting an invention without authorisation.” A patent is “a government-granted exclusive right that requires an innovative step and industrial usage of a novel invention.” Territorial right means “disclosing the invention to the society by a detailed, correct, and well-specified document to be the owner of the invention within the geographical boundary of the relevant country or region” (WIPO, 2018). A patent is a territorial and bureaucratic industrial property right registration system that protects an invention of commercial value from being imitated. Patent provides an official monopoly right to the inventor by preventing the invention from being produced, sold, used, imported or exported without permission by third parties. It is the official monopoly authorization that provides the inventor the right to prevent from being reproduced, used, sold, imported or exported for commercial purposes by third parties within the borders of the country where the patent was obtained, for a limited period of time (Prodan, 2005). A patent is a legal document that is valid for various periods of time, which provides the owner with the opportunity to benefit economically on his invention and to prohibit others from benefiting from the invention in question. In modern usage, the term patent usually refers to the right granted to anyone who invents something new, useful and non-obvious. When the Paris Convention and Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) provisions are evaluated together, one of the protection categories considered as industrial property is patents. A patent is often referred to as a form of intellectual property right, an expression which is also used to refer to trademarks and copyrights, and which has proponents and detractors (Wall, Minocha, & Rees, 2009).

A patent for an invention is granted to the inventor by the government. Patents are granted for inventions that exceed the current state of technology, that can foresee solutions to the problems of technology, and that can be applied to industry beyond institutional boundaries (Karakuzu, 2005). When a patent is granted, that right becomes the property of the inventor, which – like any other form of property or business asset – can be bought, sold, rented, or hired. The patent owner benefits from the patent right without making any distinction as to the place of the invention, the field of technology and whether the products are imported or domestically produced. Patent right, which has an important place in industrial property rights in traditional terminology, is a right related to intangible goods that are more relevant to developing countries especially in terms of being a means of technology transfer (TPE, 2010). The owner has the right to use the invention that is the subject of the patent. The rights constituting the content of the patent right can be considered as right to patent and right arising from patent in general terms. It is possible that each of these sub-rights belongs to different persons (Saraç, 2001). The inventor has the right to prohibit the invention, as well as the right to use it. The right to use, which is the positive authority provided by the patent, is the use of the invention by the patent owner or the persons to be determined. The power of exclusion, means that invention which is the subject of the patent is prevented from being produced, used or sold by thir parties for a certain period of time without the patentee's permission (Saraç, 2001, pp. 130-136). The duration of the right granted to the patent owner is not unlimited. For instance, in accordance with legal decision to the no 551 in Turkey, the duration of the patent is 20 years for the patent with examination and 7 years for the patent without examination, starting from the application date (PatKHK Article, 1995).

Literally, patents are property, which are tradable, transferable, licensable or grantable (Sherkow & Greely, 2015). The right of protection acquired by a patent prevents others from producing, using or selling this invention (Rockett, 2010, p. 317). If the same invention is made by individuals independent of each other, the right to request a patent belongs to the one who applied first or the one who has priority right over the other. The person who has the right to request a patent obtains the exclusive right to operate the invention for a limited period of time (Yosmaoğlu, 1978). Patent protection is generally limited to 20 years from the date of application. Keeping a patent right gives the innovator a legal monopoly and prevents others from taking advantage of their innovation without permission. The strong protection of the patent right not only encourages creative people with the capacity to make inventions, but also encourages investments (Odman, 2002). In general, the exclusive rights apply only to the country or region where the patent is filed and granted. In order to protect inventions in several countries, applicants often apply for patents to more than one country. As a result of this situation, the number of new inventions is increasing.

Therefore, patent family[11] data is often used to minimize or, if possible, eliminate double counting. WIPO has developed several indicators for patent families to capture the actual number of inventions (World Intellectual Property Indicators, 2022).

Patents which are granted are protected under law. If you have a granted patent, no other individual or company is legally allowed to benefit from the work in the manufacturing, using, selling or proposing to sell and importing ways. Licensed manufacturers of the patented work can create, sell, use, and import the work under the rights given to them by the granted patent and license. Granted patents essentially hand the creators and manufacturers of a protected work a monopoly over that work for a temporary period. Published patent applications for inventions do not give these rights to the creators of works, but simply say that the works might be protected in the future. The concept of patent propensity is used by economists in different meanings. Scherer (1983) defines the patent propensity "as the patent per R&D ratio," while Mansfield (1986) defines it "as the patenting possibility of a patentable invention." Arundel & Kabla (1998) defined the patent propensity "as the probability to patent a patentable innovation." It seems that the patent trend is all about the decision whether to apply for patent protection for an invention (Arundel & Kabla, 1998).

The first task of preparing a patent application is to describe the invention. The first step in the procedure to be followed in order to grant patents to inventions is to file a patent application. A patent application is usually published within 18 months from the priority date[12] in most patent offices. Patent applications filed using the PCT procedure to obtain international patent protection are published within 30 months (Compendium of Patent Statistics, 2008). However, these conditions vary according to the countries. For example, during the patent period, patented information can be included in new inventions. At the end of the patent period, the invention can be used by third parties (Maskus, 2000). There are essentially three ways of obtaining a patent

[11] A patent family is a set of interrelated patent applications filed at one or more offices to protect the same invention. The patent applications in a family are interlinked by one or more of the following: priority claim, Patent Cooperation Treaty (PCT) national phase entry, continuation, continuation-in-part, internal priority, and addition or division.

[12] Priority date is the first date of filing of a patent application, anywhere in the world, to protect an invention.

in Europe; through the national patent offices, through the European Patent Office and via the Patent Co-operation Treaty.

Patentability refers to how easy or difficult it is to meet the standards for obtaining a patent on an invention. Not all inventions can be patented. Because all inventions do not meet the patentability criteria set by national patent offices (Hall & Ziedonis, 2001). Patents can be given to product and method inventions in all fields of technology, provided that they are *new, unique and industrially applicable (useful)* (OECD, 2004). An invention is patentable when it fulfils the criteria of industrial applicability, novelty, inventiveness and patentable subject matter (Felix, 2007). Novelty is a concept that the invention, which is the subject of patents, should have. For this reason, for an invention to be patentable, it must be new, not included in the known techniques (Cornish W. R., 1989, p. 115). That is, the invention should not be in a technical field that has been applied before (Harhoff, Narin, Scherer, & Vopel, 1999). The generally accepted principle in patent law is that the invention to be patented must contain absolute novelty. Accordingly, information in the technical field that has never been disclosed anywhere in the world vefore can be patented as an invention (Oruçoğlu, 2007). Innovation is a essential requirement for the patent system. However, in order to be eligible for patent protection, an invention must be covered by patentable subject matter (TRIPs Article 27.1). An invention, in order to be patentable, must be applicable for practical purposes. If the invention involves a new process, it must be possible to implement this process. If the invention will be a new product or part of an existing product, that product must be producible. While the requirement to be industrial applicability is adopted in the British and German patent laws, it is not included in the U.S. patent law. However, this law includes the condition that the invention must be useful, that is, it must have a practical value. According to the British patent law, an invention is industrially applicable if it can be obtained or applied in any branch of industry, including agriculture (Şehirali, 1998, p. 12). Industry is human activity for the purpose of earning a continuous, independent, permitted activity to meet the needs of society (Ayiter, 1968, p. 50) (Ortan, 1991, p. 97). It is considered that the drugs to be used for diagnosis and treatment and their production methods are industrially applicable (Philips & Firth, 2001, pp. 58-61). In addition, in the field of cosmetics, activities in cosmetics and beauty salons are considered as continuous, independent and profitable activities and are included in the concept of industry (Hart & Fazzani, 2000, p. 32). Examples of technology areas that are excluded from the scope of patentable subject are; "discoveries of materials or substances already existing in nature, scientific theories or mathematical methods, plants and animals other than microorganisms, and essentially biological processes for the production of plants and animals, other than non-biological and microbiological processes, schemes, rules or methods, such as those for doing business, performing purely mental acts or playing games, methods of treatment for humans or animals, or diagnostic methods practiced on humans or animals" (WIPO, 2004). Patentability seeks to establish the breadth (or scope) of the technology covered by a particular patent. Patent breadth refers to the extent to which a patent covers the field to which it is relevant. In a sense, patent breadth helps to determine the value of a patent. The more extensive the scope of a patent, the more likely it is that rival items and procedures will infringe on it. Patent breadth and patentability can have an impact on innovation in both positive and bad ways (OECD, 2016).

According to the European Patent Convention patentability exceptions are: "Inventions that are contrary to public order or morality, plant and animal species or methods of cultivation of plants and animals based on a significant biological principles" (Ortan, 1992). In the British patent law, discoveries, scientific theories, mathematical methods, aesthetic creations, computer programs are listed as non-patentable subjects. Animal and plant species or biological procedures important for the production of plants and animals are also prevented from being patentable. In the American patent law, the limitation of non-patentable the subjects and inventions is handled more narrowly. The American system, which can be considered as one of the most liberal patent systems in the world, adopts the principle that everything made by human beings on earth can be patented (Bouchous, 2000).

Owners of invention announce their names as a result of their patents. They may also have financial rewards in return their inventions. In these aspects, patents are attractive to the inventors. Patenting inventions accelerates innovation activities by disseminating new knowledge. Gilbert and Newbery (1982) stated in their study that if firms protect their innovations by patenting, they create a monopoly power. They stated that a patented innovation is not used by others and thus the concept of innovations becoming dysfunctional called sleeping patents has emerged. This leads to the ineffective use of innovations (Gilbert & Newbery, 1982). Not all patentable inventions are patented. In some cases, firms rely instead on trade secrets, because technology is progressing so rapidly that it may be obsolete before a patent issues.

Also, in cases where technological advances are very difficult and costly to copy, patent protection may not seem worthwhile. The percentage of inventions that is patented can vary over time as well as among industries and firms (Mansfield, 1986). Firms may choose not to patent an innovation for many reasons; (i) the innovator may judge their creation to be unpatentable in legal terms, but hard to imitate; (ii) a firm may prefer not to disclose its processes, as required by patents, because disclosure could reduce expected profits; (iii) firms may wish to avoid the costs of patenting (Maskus, 2000). Two situations might emerge in the absence of patent protection: "Either all firms invest in R&D or only one firm invests and the others imitate" (Encaoua, Guellec, & Martinez, 2006).

According to Mazzoleni and Nelson, there are four theories regarding the benefits of a patent (Mazzoleni & Nelson, 1998). The first theory is that patents motivate inventions. The second theory is that patents contribute to the development and commercialization of inventions. Patents contribute to the explanation of inventions is the third theory, and the last theory is that patents provide a regular development of broad prospects. Patenting an invention has an important place in terms of economic growth, development and increasing international trade. From a micro perspective, it is extremely important in terms of encouraging R&D activities in companies. In countries where there is no strong patent protection, companies avoid transferring technology to that country for fear of imitation. This situation negatively affects foreign direct investments (Gökovalı & Bozkurt, 2006).

The features listed among the important features of the patent system should be emphasized. Governments are given some temporary rights to inventors. The financial award received by the patent holders varies depending on the special value of their patented invention. For the implementation of a patent system, the government does not need economic informations such as the cost of R&D and the value of the invention. Innovative firms compare the patenting cost with the value of their inventions when making an investment decision. Finally, the necessity to disclose patents enables the dissemination of knowledge (Encaoua, Guellec, & Martinez, 2006).

Patents and the patent system provide monopoly power to the inventor and/or the patent owner. Investors are willing to invest in high-technology companies that have strong patents protecting their technology. Therefore, patents also play an important role in securing financing for a new venture. Through a patented technology, companies can develop the opportunity to develop in a new market and sector. As a result of all these, prestigious innovative companies and the advantage of international trade can lead to country-wide developments.

2.3.2 Types of Patents

It is possible to classify patents according to the types of patent claims, the way they are examined, their relevance to the original patent and whether they are open or not. Patents are called product or method patents according to the feature shown by their claims. Accordingly, "if the invention for which the patent is claimed is related to a product, it is defined as a product patent," and "if it is related to a method, it is defined as a method patent." While multinational companies carry out 70% of world trade, they own 90% of technology and product patents (Ongun, 2009, p. 24). "The patent obtained as a result of the first application for an invention is called the original patent." "The patent to be obtained depending on the original patent is defined as an additional patent." The supplemental patent is subject to the original patent. For this reason, the protection period of the additional patent continues for the remaining protection period of the original patent (Şenkazan, 2019). According to the way of examination, patents are divided into two as examined and unexamined patents. Patent system without examination is regulated in article 60 and article 61 of delegated legislation no 551, patent system with examination is regulated in article 62 and article 63. According to the way the patent is examined, the protection period provided by the patent is also determined. According to article 72 of the delegated legislation no 551, the protection period of the patent without examination is 7 years; the protection period of the examined patent is 20 years (Tekinalp, 2002).

The U.S. Patent and Trademark Office (USPTO) issues several different types of patent documents offering different kinds of protection and covering different types of subject matter. Utility patent is issued for the invention of a new and useful process, machine, manufacture, or composition of matter, or a new and useful improvement thereof, it generally permits its owner to exclude others from making, using, or selling the invention for a period of up to twenty years. Approximately 90% of the patent documents issued by the USPTO in recent years have been utility patents, also referred to as patents for invention. Design patent is issued for a new, original, and ornamental design embodied in or applied to an article of manufacture. The design patent owner has the authority to prevent others from making, using or selling the design. Design patents issued from applications filed on or after May 13, 2015 shall be granted for the term of 15 years from the date of grant. Plant patent is issued for a new and distinct, invented or discovered asexually reproduced plant including cultivated sports, mutants, hybrids, and newly found seedlings. Reissue patent is issued to correct an error in an already issued utility, design, or plant patent, it does not affect the period of protection offered by the original patent. Defensive publication is issued instead of a regular utility, design, or plant patent, it offers limited protection, defensive in nature, to prevent others from patenting an invention, design, or plant. Patent owners have some rights over their patents. The product and/or process mentioned in a patent cannot be used, sold or imported by others without authorization of the patent owners. Three forms of patents may be applied for; (i) invention patents require significant non-obviousness and as such a discrete advance in technology; (ii) utility models tend to be awarded for incremental improvements of existing products and technologies; (iii) industrial designs protect the aesthetic or ornamental aspects of a commercial article (Falvey & Foster, 2006).

Licensing of a patent is carried out for a specific purpose, for the agreed period, in a specific region and according to other agreed conditions. Thus, another person/ organization has permission to use and/or sell the patented invention. Licensing of a patent can be issue for many reasons. For example, a patentee may have manufacturing facilities, but these may not be large enough to meet market demand. In this case, a patentee may decide to license its patent to another manufacturer to strengthen the revenue stream. The patent owner may not have the necessary manufacturing facilities. For this reason, he choose to allow others to produce and sell patented invention in exchange for payments. If the patentee wants to concentrate on a single geographic market, he may choose to license another person/organization in other geographic markets. In summary, licensing of a patent enables the establishment of a mutually beneficial cooperation (WIPO, 2004).

2.3.3 Emergence of Patent System and Patent Laws

While patents are one of the types of IPRs; they are also the most strongly regulated of these rights (Besen & Raskind, 1991, p. 6). The evaluation of the patent as a registration mechanism for inventions emerged in the early 18th century, and the exclusive use of the invention by the inventor emerged half a century later. Therefore, there was no patent in today's sense before. In addition, it is observed that the meanings given to patents have changed over time (Cornish & Llewelyn, 2003, p. 114). The first letters patent known in world history was given by the king to a Dutch weaving merchant named John Kempe in 1311 so that he could trade in England (Bainbridge, 2002, p. 311). In this document, the powers of the merchant in terms of trade were counted and the control of the king over trade was ensured in this way (Cornish & Llewelyn, 2003). “The Statute of Monopolies” was issued in 1623 in order to control this practice, which is abused from time to time (Keskin, 2003, p. 19). These documents provide those who discover or import new technology the right to use that technology for a sufficient period of time to establish their business (Soyak, 2005, p. 3). In the 1400s, Venice, which became a trade monopoly in Europe and the rest of the known world, was an industrial pioneer; shipbuilding, glasswork, lace making and printing (Prager, 1950). The first examples of patents emerged especially in these fields of activity and paved the way for regulations in countries with intense commercial relations. One of the earliest registered patent holders, the great architect Filippo Brunelleschi, was given three years of exclusive rights to his invention for heavy-duty transport on the Arno and other rivers. In the field of printing, a patent was granted to Venetian printer Aldus Manutius for a new printing character, which would later be called a proprietary design (Frumkin, 1945). Around 1440, Johannes Gutenberg created the printing press and movable typeface, which led to the creation of the first copyright system in the world. It is claimed that the first real patent was granted to the famous architect Filippo Brunelleschi in 1421 in the Republic of Florence for his ship designed to transport Carraran marble to his famous architectural work, the Duomo of Florence (Bülbül & Özbay, 2010, p. 5). It is not certain whether the first patent started in Venice or Florence, but it is certain that the first patent law was issued in Venice (Bülbül & Özbay, 2010, p. 41). The law, which was used in Roman law and put into practice in Venice on March 19, 1474 in order to encourage research on fine arts, is officially considered the first patent law (Machlup, 1958, p. 2).

In the USA, the first patent law was enacted in Massachusetts in 1641, but the first federal law was passed in 1790 (Erdem, 1999, p. 49). The French patent law was based on the principle of granting patents without examining inventions and came into force in 1791. In 1815 Russia, in 1864 Italy, and in 1877 Germany patent laws came into force. On the other hand, Japan started to protect inventions in 1885 with the *Patent Monopoly Law*. The Ottoman patent law was translated as it was from the French patent law and entered into force in 1879 (Soyak, 2005, p. 3). With the Paris

Convention on the Protection of Industrial Property in 1883 and the Bern Convention on the Protection of Literary and Art Works in 1886, the international intellectual property system began to strengthen. With the Paris Convention, which was signed as a result of the increase in national patent laws, a fair evaluation of patent applications in the contracting states was ensured. As a result of these developments, the international patent system has evolved to manage relations between states and to deal with the difficulties caused by the territoriality of patents.

It is generally accepted that the main purpose of the patent system is to advance the society by providing economic and technological development (Saraç, 2001, p. 485). The elements that make up the patent system are listed as patent law, patent institute that will carry out the procedures stipulated by the patent law, information and documentation opportunities, training, patent attorneys, specialized courts (Yalçıner & Köker, 2020, p. 167).

The patent system encourages the use of technology to create new products and services for both the inventor and its competitors. Patent has functions such as protecting the invention, which is the product of thought, encouraging inventive activities, securing technical, economic and social benefits (Karakuzu, 2005, p. 189). One of the purpose of the patent system is to provide innovators with exclusive rights to prevent others from using their inventions without the patentee's consent. However, the expands of innovative activities is considered one of its objectives. The existence of the patent system provides the explanation of the technical details of the invention. Thus, the technical information stocks of the public expand and a competitive environment is created among innovators (WIPO, 2008). Patent rights encourage technology transfer by providing legal certainty to its owners. In this respect, the patent system creates commercial property rights and strengthens technology transfer both nationally and internationally (Maskus, 2000).

The expansion of public technical information stocks and thus the increase in social benefits across the country are thanks to a strong patent system and policy. In this respect, patents are one of the most important sources of information for technological knowledge (WIPO, 2008). For the commercialization of knowledge, a market for technologies must be created. The patent system plays a very important role in technology transfer between the public and private sectors. University patenting promotes the knowledge transfer between the university and companies. On the other hand, the patent system has a separate importance as it reduces the duplication of R&D

activities. In a country with a strong patent system, information is easy to disclose, disseminate and access information. In the absence of the patent system, inventions will tend to remain confidential and information about the invention will not reach the public (WIPO, 2008). In this case, companies will also be unwilling to share their know-how due to the risk of imitation (Maskus, 2000).

The advantages of patents have two aspects. First, patents legally assure inventors that the commercial value of their ideas is protected. Secondly, with the patent process, the inventor discloses all the details of his invention. Third parties or companies have the opportunity to create other useful products inspired by these ideas. In both cases, patents tend to encourage invention (creation of new ideas) and innovation (successful commercial application of new ideas) (Miller, Leroy, & North, 2012, p. 102).

In countries without patent laws, inventors depend entirely on secrecy, lead time, and other alternatives to patents to protect their IP. In countries with patent laws, inventors can use legal protection to establish exclusivity in any industry, so that factors other than the effectiveness of secrecy determine the direction of technical change (Moser, 2005). Over time, new and more powerful governing bodies have emerged for the design and implementation of patent policies. For example, reforms were launched in US in the late 1970s, and the centralised court system was established in 1982. This was effective in strengthening patent rights in the US. The EPO, a comprehensive and central system across Europe, was established in the late 1970s. Japanese government created the “Intellectual Property Strategic Council” in 2002 in order to establish a national strategy for intellectual property and to implement relevant policies. (OECD, 2004).

In the near future, the patent system will face major challenges due to increasing globalization and the overuse of digital channels as a means of diffusion. More global policies will be needed to ensure that the patent system can continue to fulfill its mentioned role fostering innovation and technology diffusion.

2.3.4 Agreements Related to Patents

Due to the globalization of markets and the increase in international trade, at the end of the 19th century, there was a growing need for common international standards in the enforcement and protection of patents and other IPRs. Particularly, inventors seeking to obtain patent protection for an invention in more than one country faced the problem that a patent application filed in one country could be considered as novelty-destroying prior art in another country (European Patent Academy). Seeking patent protection in a foreign country can be difficult for many reasons: Possible discriminatory treatment, differences in national laws, cost and time issues related to filing and processing patent applications. International agreements have been organized to solve undesirable problems that may occur and to reduce the difficulties of patenting in a foreign country (WIPO, 2003). Under this heading, regional and international patent agreements are presented chronologically with their most important features.

Multilateral agreements, international organizations, regional conventions and bilateral agreements constitute the international patent legal regime. Since a patent is valid only in the country in which it was issued, it is subject to national law and litigation decided in national courts. International agreements, such as the 1994 TRIPs agreement, which is overseen by the World Trade Organization (WTO), tend to place restrictions on what national laws and policies can do (OECD, 2004).

The first multilateral agreement in the field of patents is the Paris Industrial Property Convention, signed in 1883 and amended in 1900, 1911, 1925, 1934, 1956, 1967 and 1993. In this aspect, the contract is defined as the first international institutionalization of the patent system (Soyak, 2005). This contract is considered the constitution of national patent laws. The main issues regulated in the Paris Convention are; common provisions regarding industrial property rights,[13] prevention of unfair competition, priority right, national treatment principle. On January 15, 2002, 164 countries, mostly developing countries, became party to the Paris Convention (Maskus, 2000).

The Patent Cooperation Treaty (PCT) was signed in Washington on June 19, 1970, amended in 1979, and amended again in 1984. The states party to the Patent Cooperation Agreement have established a union called “Regulations under the Patent Cooperation Treaty” in order to cooperate in filing, researching, examining and

[13] According to priority right, anyone who files a patent application has the right to file an identical application in another signatory country of the Paris Convention within a certain time frame without being exposed to the risk that their own first application may be assessed as novelty destroying in subsequent application procedures in other jurisdictions. The main effect of priority right is that, in terms of novelty, the filing date of the first application is considered to be the effective date for determining the state of the art of the subsequent applications within twelve months. Source: https://e-courses.epo.org/wbts_int/litigation/Priority.pdf.

providing technical services for the protection of inventions. The main purpose of PCT is to ensure that patent applications are concluded as quickly and clearly as possible by providing a standardization to patent applications. As of March 01, 2023, the PCT, to which 157 countries are party, has been adopted in most of the six continents. A single international patent application can simultaneously grant innovation protection in all PCT member states according to a patent cooperation agreement (Pınar, 2004). PCT is accepted as the most advanced international agreement signed in the field of patents after the Paris Convention (Maskus, 2000). The inventor will be able to obtain protection in any member country in a more economical way without having to apply to each member state individually[14] (Canbolat, 2007).

The European Patent Convention (known as the EPC or Munich Convention) was prepared in 1973 and signed in 1977 with the aim of protecting nations and strengthening cooperation between European states in this regard. EPC is a regional agreement within the PCT. According to Article 1 of the Convention, *European law* regarding the granting of patents has been established for all member states. In Article 2 of the same contract, it is stated that "the patents granted under the authority of this contract will be called *European patent*" and this patent will be subject to the same conditions in each of the member states (EPO, 2016). After a European patent is granted, the patent proprietor will be able to request unitary effect, thereby getting a *Unitary patent* which provides uniform patent protection in up to 25 European Union (EU) Member States. Unitary patents will remove the need for complex and costly national validation procedures. Unitary patents will confer truly uniform protection since the substantive patent law governing the scope and any limitations of the rights and the remedies available in cases of infringement has been harmonised in the Agreement on a Unified Patent Court (EPO, 2021). The purpose of the convention is to increase cooperation between European countries on the protection of inventions, to establish a valid patent granting system in all member countries, and to establish a common patent law among European countries. Thus, it becomes possible to obtain a patent protection in a shorter time and at a lower cost. Applications can be made to the

[14] The patent offices of Australia, Austria, Brazil, Canada, Chile, China, Egypt, Finland, India, Israel, Japan, the Philippines, the Republic of Korea, the Russian Federation, Singapore, Spain, Sweden, Turkey, Ukraine, the United States of America, the European Patent Office, the Nordic Patent Institute and the Visegrad Patent Institute act as International Searching Authorities under the PCT (status on May 20, 2019).

EPO headquarters in Munich, the EPO center in the Hague, the service unit in Berlin and patent offices in all member countries. Thanks to this centralized system, it is possible to win the European patent granted by the EPO for new inventions in one or all of the member states with a single application form (Şehirali, 1998).

The Strasbourg Agreement on the International Classification of Patents (IPC) was drawn up in 1971 and revised in 1978. The main purpose of the agreement is to both facilitate the process and provide international standardization by making use of a uniform classification in the patenting of inventions in the international arena. Special symbols and unique ranking systems were necessary in patent applications to express the technical disciplines to which the application was related. For this purpose, patent offices have started to develop some systems for the classification of patents (Şehirali, 1998, pp. 30-31). According to the IPC system, the technology is divided into eight segments (AH) containing 70.000 subgroups. Accordingly, A symbolizes human needs, B the application of processes and transportation, C chemistry and metallurgy, D textiles and paper, E fixed structures, F mechanical engineering such as explosion-weapons-heating and lighting, G physics, H electrical subjects. While these letters indicate which subject the invention deals with, the elaboration of the subject is in the sub-classes (WIPO IP Portal, 2023). Thanks to the patent classification system, all inventions are categorized according to a central classification system and thus universal patent searches can be carried out. In this way, applications that fall into the same technological class all over the world can be easily separated.

The Community Patent Convention (CPC) is the most comprehensive agreement on patent and patent protection in the European Community. Preliminary work on the regulation started in 1959 and was signed by nine member countries of the Community in 1975. The Convention was amended before it entered into force, and finally, as a result of the 3rd Luxembourg Conference, a new contract text was prepared in 1989, including the provisions that would put the contract into effect (Charlesworth & Cullen, 1994). The purpose of the CPC is to achieve unity and integrity in the granting and protection of the European Community joint patent. For this purpose, a patent that will be effective in all community states will be granted and common patent law will be created in the member states, so the c*ommunity patent* will give rise to the same provisions within the sovereignty of the member states (Wyatt & Dashwood, 1993, p. 572).

The North American Free Trade Agreement (NAFTA) entered into force on January 1, 1994. NAFTA, which is the model of two developed countries USA and Canada to establish a free trade area with one developing country Mexico; it aims to liberalize trade and encourage investment among its members (Arı, 2003). The agreement is a regional agreement that regulates the patent issue and its provisions are parallel to the GATT-TRIPs text.

Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs) was established during the Uruguay Round (1986-1994) of trade negotiations in order to strengthen the international IPRs regime (Falvey & Foster, 2006). The TRIPs Agreement, which forms part of the WTO regime, entered into force on 1 January 1995. The TRIPs agreement is the first comprehensive and global set of rules covering IPRs protection (Falvey & Foster, 2006). The TRIPs agreement's main goal is to protection and enforce IPRs. In addition to these, it has been prepared with a very broad perspective, including the development of technological innovations and serving social and economic welfare. Economic fluctuations experienced by industrialized countries due to piracy and counterfeiting have created a stronger need for IP protection (Blakeney M. , 1996) (McGrath, 1996). One of the objectives of the TRIPs agreement is to harmonize IPRs protection, which provides minimum standards in member states (Maskus, 2000). The TRIPs agreement includes five key areas (Odman, 2002): The way in which the basic principles of the trading system and international IP agreements are implemented. Ensuring adequate protection of IPRs. Enforcement of these rights by the countries that are party to the treaty. Settlement of disputes between WTO members on IPRs. Temporary arrangements that will be valid until the new system takes effect.

Multilateral organizations play an important role in encouraging the spread of their findings on the economic effects of protecting IPRs to all interested parties and countries. Multilateral organizations also play an important role in fulfilling knowledge needs by promoting collaboration and knowledge sharing among governments.

CHAPTER 3

3. PATENT AND ECONOMIC GROWTH IN THE OECD

The concept of growth, which began with David Ricardo and gained different views with Karl Marx, was heavily debated until the early 1950s under the influence of Keynes, according to the historical development of economics. Classical economists did not take into account the effects of economic growth on the environment and natural resources. The neo-classical theory states that in the long run, the per capita income levels of countries will converge and the welfare gap between countries will automatically disappear (Yülek, 1997). In endogenous growth theories, technological development is taken internally and human capital gains importance (Romer, 1990). Economic growth was focused only on increasing per capita incomes and increasing the level of welfare, that is, on economic growth until the 1970s. After this year, it was started to be expressed that social development should not be limited to the economy, but should also cover the environment, nature and the needs of future generations (Acar, 2001).

The important thing is to ensure growth in economies, and more important thing is sustainable growth. Sustainable growth is a multidimensional phenomenon with sociological, ecological, economic and cultural aspects. Economists have emphasized that innovation activities and technological development are of great importance for sustainable growth. Patents are powerful tools to encourage the creation of new technologies and industries. In this context, it will be possible to talk about sustainability if innovation and patents are encouraged and made an important element of economic policies.

This part of the thesis consists of three main titles. In the first title, the economic importance of the patent; under the second title, the effects of patents and the patent system on economic growth is examined. Finally, since the data of OECD countries are empirically examined in the thesis study, the establishment and objectives, general economic structure, patent policies, patent and innovation-based statistics of OECD countries are mentioned.

3.1 The Economic Importance of the Patents

Patent regimes have gone through significant changes over the last two decades. Most of these changes have been aimed at strengthening the exclusive rights granted to patentees, broadening their scope and facilitating their enforcement. In this respect, there are several reasons why patents are important. Firstly, patents provide inventors with community recognition and financial rewards. Secondly, innovations are encouraged and spread. Thirdly, protection stimulates research, which results in technological development. Fourthly, it enables the inventor(s) to recoup their investment in time and money spent in research and development to develop their ideas. Lastly, the use of patent documents enables future researchers not to re-invent the wheel, just to mention a few (Pacra, 2008).

Changes in the social, economic and technological fields in the world economy are explained with the concept of new economy. In the context of the new economy, knowledge takes place as the basic production tool (Bayraç, 2003, pp. 42-49). Danniel Bell introduced the concept of post-industrial society in his 1973 work "The Coming of Industrial Society: A Venture in Social Forecasting." Bell emphasizes that the dynamism of the knowledge society is driven by knowledge rather than manpower or energy, and that people in demand are skilled experts equipped with the qualities society needs (Dikkaya & Özyakışır, 2006). Changes in information technology with social transformation, globalization and knowledge have an important place in the formation of the new economy. Technology, defined as "the application of knowledge and knowledge-based methods to any business, is one of the basic elements of the new economy" (Bayraç, 2003, pp. 42-49). The most important components of technology, which is the key point for economic development, are knowledge and innovation. Because; the importance of intellectual products based on knowledge, innovation and creative processes is increasing day by day, countries encourage R&D activities that lead to technological innovation. Countries are subject to national and international regulations to protect the intellectual products that emerge as a result of R&D

activities. There is no doubt that innovation is one of the key determinants of productivity and economic growth. Nowadays, the transition to knowledge economies in the information age has made technological development inevitable for sustainable high growth and a welfare society. Both the limited growth that countries can achieve with limited resources and the new situations brought by the information age have increased the importance of technology in science and economic policies. R&D activities, which are at the core of technological development, have been widely supported by practices such as incentives and subsidies. Governments typically use many different policy tools to stimulate the level of innovation in their economies. These consist of instruments such as financing specific projects in government laboratories, R&D tax breaks, subsidies, or general financing for university research. In addition to these policy tools, there are also framework laws such as intellectual property and competition laws. Intellectual property protection in the form of patents is recognized as a way for governments to encourage investment in the creation and diffusion of new knowledge. Intellectual property laws encourage investment in creating and developing innovations (OECD, 2016).

Patents are a means of protecting inventions developed by institutions or individuals and, therefore can be interpreted as an indication of invention. Patents protect inventions. Patents can also provide information about inventors' mobility and networks, making it possible to track the dissemination of knowledge (OECD, 2009). One of the most important features of patents is that they deal with new knowledge embodied in an innovative product or process. New knowledge that makes possible the production of new products and/or processes obviously carries considerable economic value (Arrow, 1962). It provides the means for the dissemination of research results to the national and world economies through technology and personal contacts embodied in patents, scientific literature, technology licenses, capital, and intermediate inputs (Cameron, 1996). Another important feature of patents is that it gives the inventor limited monopoly rights. A patent provides an incentive for the original patent holder to submit their invention to a firm that can both advance and commercialize it (Mazzoleni & Nelson, 1998). On the other hand, a patent refers to the success of a firm resulting from the commercialization effect of the patent. Patents provide competitiveness to the inventor, as it protects a new and useful idea. Patents cannot be excludable; in other words, once the public goods are available, it is not possible to prevent individuals from benefiting it (Friedman, Landes, & Posner, 1991). Patents have been viewed as valuable because they provide a quasi-monopolistic option to exploit specific knowledge areas for specified periods of time (Griliches, 1981).

In the endogenous growth literature, theoretical models have been built on imperfect competition market structure and patenting has been accepted as the result of successful production of valuable knowledge. So much so that patenting is a direct function of R&D activities. Patents are the main factor that guarantees return on private sector R&D investments. Allocating resources to R&D investments leads to the production of knowledge, which can be patented in the future (Pakes & Griliches, 1984). By creating transferable property rights, patents help to structure know-how (Foray, 2004). In order to develop new products and processes, certain firms rely on in-house R&D. Some companies make R&D cooperation agreements to access external knowledge, share the risks and costs of innovation with other organizations and speed up the innovation process. Making R&D partnerships will increase the need for patent protection, as it requires the firm to share its know-how with external organizations. Once patented, a firm's knowledge-base and innovation output become useful tradable assets when negotiating future cooperation agreements. Patents, a legal protection mechanism, are also helpful in clarifying property issues on common developed knowledge (Chen & Puttitanum, 2005). Patents, which are becoming increasingly popular due to their economic value, has become an important element in corporate business management. Companies form alliances with each other to increase the number of intellectual property assets that contribute significantly to business value and create a competitive advantage in the market. Competitive position in the market is a very important element for the company. Patents are seen as a decisive condition for entrepreneurs to obtain funds from risk capitalists. Patents have a positive effect on competition as they increase market entry and firm formation. Small companies can achieve competitive advantage against to large companies thanks to their patent portfolios (Gans, Stern, & Stern, 2022). Patents provide a basis for longer-lived competitive advantage because they can improve a firm's productivity and constitute an option for exploitation of a particular use of knowledge (Bloom & Reenen, 2002). More importantly, breakthroughs can extend the duration of an industry's attractiveness by initiating another cycle of evolutionary innovation (Nelson & Winter, 1982). The effect of firm size on patenting is widely examined in the literature. Schumpeter (1942) emphasizes that large firms are more innovative than small firms in his hypothesis. The econometric analysis of van Ophem et al. (2001) also shows that the size of the firm has a positive effect on the number of patent applications (Ophem, Brouwer, Kleinknecht, & Mohnen, 2001).

In last ten year, the importance of innovation as a driver of competitive advantage in OECD economies has grown. The number of patents of a country also shows the innovation potential of that country (Göçer, 2013, pp. 219-220). Increasing numbers of patenting in companies have facilitated co-operation between companies via market-based knowledge exchanges (OECD, 2004).

The main goal of patents is to foster innovation in the economy; however, the patent system is not the only tool for encouraging innovation. Other tools used to protect IPRs in the absence of patents are copyright and trademarks (Barton, 1998). Through regulations such as patent rights, knowledge and technology become market goods. Since the production of new knowledge and technology requires a large investment, companies want this knowledge and technology to remain unique to them; that is, they want a monopoly on the new knowledge and technology produced. In this context, patenting may be an approach they do not prefer (Yumuşak & Aydın, 2005).

In the studies conducted by Arrow (1962), Nordhaus (1969) and Romer (1990), innovation has been defined as knowledge production. Knowledge is inherently non-rival. That is, the amount of knowledge does not change or decrease when used by others. Knowledge is available to others without decreasing its value when produced, and no additional resources are needed when consumed. Once the knowledge is produced, it is not possible for others to benefit from it, because knowledge has a non-excludable character. As a result, innovation and knowledge can be used by anyone unless they are legally protected. Non-rival and non-excludable features of knowledge require public regulations. Otherwise, market failures may occur. Patents have been generally considered a valid policy instrument to overcome such market failure, as an ex-ante incentive mechanism giving the inventor the exclusive right to use or sell its invention (Encaoua, Guellec, & Martinez, 2006).

Public disclosure of the technical knowledge contained in the patent encourages firms to make alternative and/or new inventions by mobilizing them. Thus, copying of inventions is also prevented. Moreover, these new inventions make new knowledge spread. Thus, the process that provides more innovation and continuous improvement in society welfare occurs (WIPO, 2004).

3.2 The Effects of Patents and the Patent System on Economic Growth

Adam Smith embraces innovation as both a cause and a result of capital accumulation necessary for economic growth. He defines the factor in the emergence of technological development as the profit motive of the capitalist. The source of capital accumulation, which David Ricardo put on the basis of his economic growth model, is technological development. Robert Solow stated that technological development will create growth, and growth will create higher growth. Therefore, a dynamic structure emerges in which the economic system grows by accelerating continuously as a result of technological development. Influenced by the works and ideas of Karl Marx, Schumpeter was the first economist to emphasize that “the system is in a constant state of renewal, destroying old factors and creating new ones, and that innovation is the driving force of growth.” According to Schumpeter, innovation is one of the most important element of economic growth. With the effects of developments in information and communication technology and globalization, information has become the main competitive element. In knowledge-based economies, the most important inputs are intellectual products. For these reasons, countries encourage innovations through studies such as patent support programs (Gülmez & Akpolat, 2014). In the neo-classical growth model, the rapid industrialization process in the world has been formulated and it has been shown that capital accumulation is necessary for long-term economic growth. Modern growth theories have argued that economic growth cannot be explained by capital accumulation within the framework of neo-classical growth theories. In this regard, Romer (1986) and Lucas (1988) made the first studies by explaining the increase in productivity in production. The second wave of modern growth models is based on R&D. In endogenous growth models based on R&D activities, it is underlined that the R&D sector is important in ensuring sustained economic growth and for this reason, the human capital and knowledge stock in the R&D sector should be supported. With the inclusion of technological development in the production function, it has become necessary to examine the effects of indicators such as R&D activities, public policies, knowledge production, and human capital on economic growth. The output of R&D activities is innovations. Innovations are recognized as one of the main components of economic growth. The innovation process consists of different stages such as basic research, product design, commercialization, and once each stage in this process is completed, competitiveness and economic growth are achieved (Memiş, 2012). Innovations increase firm profitability, and when firm profitability increases, capital accumulation increases. More innovations increase capital accumulation by increasing the marginal product of capital, and further capital accumulation increases innovations as successful innovations increase profitability (Aghion & Howitt, 1999, pp. 102-114). In Romer's model, it is explained that the emergence of new inventions as a result of R&D activities, the realization of production by obtaining the patent of new inventions, that is, the emergence of innovations and that these innovations are the source of economic growth (Gülmez & Akpolat, 2014). While the importance of R&D activities increased after the Industrial Revolution, systematic R&D and applied scientific research established by the USA since the 1980s led to radical changes in the economy. It is essential for companies to invest resources in developing production plans for new products in the R&D model developed by Romer (1990). In this model, the R&D efficiency of each firm increases in proportion to the knowledge capital stock. Then, to explain economic growth, Lucas (1993), Sala-i-Martin (1995) and Barro (1996) emphasized the importance of innovations and new technologies in this sense. The historical process of growth models shows that innovation is an indispensable element. We can reinforce this with Schumpeter's (1943) famous phrase that a theory of growth without innovations (new technologies) is like Hamlet without a Danish prince (Gülmez & Yardımcıoğlu, 2012).

In the 21st century, the success of countries in transforming their traditional economies into an innovation economies determines their sustainable economic growth and social development performance (OECD, 2016). Patents are important for countries in many ways, both economically and socially. Patents are considered as an indicator of how a country benefits from the knowledge pool of society. Since having new technologies increases the competitiveness of countries, countries that can benefit from the new knowledge contained in patents may get ahead in commercial life (Penpece & Güğerçin, 2014).

The fact that economic growth rates vary across countries has been a subject of study for economists. As a result of these studies, it is generally accepted that that knowledge and innovation are effective on economic growth (UNCTAD, 1975). The role of patents in economic development is case-specific, both because of variations from industry to industry and differences between countries. The number of patents, which is an indicator of the inventions made by the countries, is important in terms of showing the R&D capacity of the country and measuring the output based on R&D. Research at the cross-country, country-level and company-level shows that innovation as measured by R&D or patenting has a positive impact on economic productivity. R&D activities or patenting rates show that companies increase their market share and profitability. Patenting has exploded over the last decades. In 1983 in the United States, 59.715 patents were issued; by 2003, 189.597 patents were issued; and in 2010, number of 244.341 new patents were approved. In less than 30 years, the flow of patents more than quadrupled (OECD, 2008). According to WIPO database, worldwide patent filings increased by 3.6% in 2021 and thus patent filings exceeded 3.4 million.

To understand patents in practice, it is necessary to examine the lifecycle of industries (Jovanovic & MacDonald, 1994) (Scherer, 1990). Typically an innovative industry has a competitive entry into the market as many innovators strive to bring their products to market. In these early stages, many firms bring different versions of the new product to the market (e.g. the American auto industry in the early 20th century or the software industry in the 1980s and 1990s) while demand for the new product grows rapidly and the quality of products is improved rapidly. As the industry matures, demand stabilizes and becomes much less price elastic; the scope for cost-reducing innovations decreases; the benefits of monopoly power grow, and the potential for additional product innovation shrinks. At this stage of the industry lifecycle, rent seeking becomes important and patents are widely used to block innovation, prevent entry, and encourage exit (Boldrin & Levine, 2013).

In 1958, Fritz Machlup reviewed how economists evaluate the patent system. He reported that there are views within society that patents create monopolies and that in many cases patents are not even necessary to encourage invention. For this reason, he argued that economists tend to be negative about the value of the patent system to society (Machlup, 1958). There are some transaction costs when applying for patents to patent offices. There are also some fees for the protection of patent rights before a patent application is approved and after a patent granted. Fees must be paid before a patent application will be examined or granted, and to maintain patent rights once granted. Therefore, asserting patent rights, or challenging those of a competitor, may be costly and difficult for small and medium-sized enterprises (Andrews, 2002). The negative effects of having excessively strong IPRs have been an issue of particular importance for developing countries. Because new innovations (R&D expenditures) are mostly concentrated in developed industrial countries, and most of the progress in less developed countries consists of adapting technologies from more developed countries to the conditions of the developing world (Stiglitz, 1999). But Machlup's own view was that there were no good models to replace the patent system and that it served some useful purposes (Machlup, 1958). The existence of a patent system ensures that patent holders can both register their inventions and allow foreign inventors to use their technology (inventions) (Blakeney M. , 1987).

Arrow (1962), Arora (1994) and Merges (1995) conducted a study on the problem of an inventor selling an invention to someone else without legal property rights. They concluded that licensing transaction costs would reduce the propensity to take ownership of an invention. Strong patents would then also serve the purpose of providing incentives to invent for parties who are limited in the extent to which they can use the invention themselves, by facilitating the sale of rights to an invention. The issues of the consequences of greater patent duration or scope are more complicated if an invention is not only useful as is, but also provides the basis for second-generation inventions. Arrow especially called attention to the possibility that the principal use of some inventions is as input for further inventions (National Research Council, 1997). Chu et al. (2020) show that patent protection has differentiated effects at different phases of economic development. According to Chu, the strengthening of patents could boost economy at earlier stages including the take-off in contrast to the limiting effects of patents in the long run (Chu, Kou, & Wang, 2020).

Possessing a patent may help a company to grow by capitalising on the market potential of its inventions. Small companies may use patents to get financial support. In addition, patents stimulate the growth of national industry because local companies that hold patents can attract overseas investment and develop products for export (Drahos, 1999, p. 445). Profits generated by patent exploitation can be invested in further R&D, which may stimulate commercial and industrial growth. More R&D activities mean more innovation and new technology. Patents resulting from innovations increase technology transfer and investment. For this reason, firms need strong patent protection to be able to disclose their technology freely (İdris, 2002). Within the firm, patents are used not only for motivation but also as a performance indicator to measure the performance of R&D staff and other technologists.

Patents facilitate technology transfer by encouraging the entry of foreign technologies, making technological knowledge accessible through patents. In sum, the existence of an environment conducive to technology transfer in a country means the existence of a strong patent system. In surveys conducted in the US, Europe, and Japan in the mid-1980s and 1990s, it was found that patents provide a competitive advantage to companies, although there are differences across industries. In the study, companies in the biotechnology, pharmaceutical, and chemical sectors reported that patents were extremely important in maintaining their competitive advantage. Firms from other sectors reported that patents play a secondary role as a means of protecting their inventions (Levin, Klevorick, & Nelson, 1987).

Patents encourage R&D activities in universities, research and design centers. As in firms, R&D activities at universities increase licensing revenues. In a university with increased licensing revenues, more R&D activities can be financed. This will positively contribute to economic growth by encouraging more innovation and invention and increasing high technology.

Patents encourage knowledge sharing, by requiring the disclosure of an invention's specifics in exchange for the exclusive right to commercialize it. Disclosure of knowledge with society through the patent protection and system benefits society's progress more than if the knowledge remains secret (Goldstein & Golod, 2002). In this way, researchers may examine a patented product and discover methods to enhance it. Access to patented innovations may also make research possible that otherwise would not be. In this regard, patents limit research duplication and motivate researchers to improve existing inventions.

The economic significance of a patent depends on its scope. In other words, the broader the scope, the greater the number of competing products and processes that could infringe the patent. According to macroeconomic perspective, the patent system affects the economy as a whole. The economics surrounding group of patents or a single patent revolves around the balance between the expense of maintaining the patent(s), and the income derived from owning those patents (Kryazhimskii & Watanabe, 2002). The benefits of new inventions are available to everyone in the relevant field and therefore provide advantages to all parties in that field. The effects of patents in a particular market can vary widely according to the type of market and whether there are other barriers to entry (e.g. regulatory versus business methods).

Patents give the patent holder exclusive rights. Third parties cannot commercially utilize the invention for 20 years from the date of the patent application thanks to this right. Firms or individuals can earn higher returns on investments through exclusive patent rights. In case of non-use of the patent, the patented invention may be sold to another entity or licensed for commercialization. Patent portfolios are considered as an indicator of a company's high level of expertise and high technological capability. For this reason, patents are perceived by business partners, investors and shareholders as a positive image for businesses. This also increases the market value of the company.

3.3 An Assessment of Patents and Economic Growth in OECD Countries

The economic and social development policies of countries that encourage innovation are focused on innovation. The OECD states that increasing welfare and employment in a country is proportional to that country's capacity to innovate and adapt. In an economy where there is sufficient innovation activity, new firms are established; existing firms maintain their existence and gain an increasing competitiveness (OECD, 2008).

3.3.1 Economic Structure of OECD Countries

In this section of the study, information about the OECD countries, which are the country group used in the analysis, and their general economic structures will be provided. The Organization for Economic Co-operation and Development is an intergovernmental organization of 38 member countries, established in 1961 to stimulate economic progress and world trade. It is a forum where member countries define themselves as committed to democracy and market economy, providing a platform to compare policy experiences, seek answers to common problems, identify good practices and coordinate the domestic and foreign policies of its members. The official founding members of OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States. Article 1 of the “Convention on the Organisation for Economic Co-operation and Development”, which was signed in Paris on 14 December 1960 and entered into force on 30 September 1961, lists the objectives of the organization as follows**:** To contribute to healthy economic expansion in the economic development process. To capture the highest sustainable economic growth, standard of living and employment by maintaining financial stability in the member countries, thus contributing to the development of the world economy. To contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations (OECD, 2004).

Many countries acknowledge that innovation is key to sustainable long-term growth. In addition, since patents are an indicator of innovation, it would be useful to first illustrate the innovation situation in OECD countries. Among OECD countries Belgium, Denmark, Finland, the Netherlands, and Sweden are innovation leaders with innovation performance well above the EU average. Austria, France, Germany, Ireland and Luxembourg are strong innovators with performance above the EU average. Between 2021 and 2022, innovation performance has improved in most strongly in Czechia, Ireland, and Finland (at 7.5%-points or more), and has declined Estonia, France, Germany, Italy, Latvia and Luxembourg with performance declining strongest in Estonia (-8.9%-points) (European Innovation Scoreboard, 2022).

The importance of each activity varies across OECD countries with the most important sector groups being industry; distributive trade, repairs, transport, accommodation, food services, public administration, defence, education, human health and social work activities. The share of industry in total value added has trended downward in recent decades. The share of agriculture in total value added within the OECD is generally small. In only five countries (Turkey, Iceland, New Zealand, Hungary and the Slovak Republic) does agriculture account for more than 4% of total value added. Real household income per capita in the OECD grew by 0.2% in the third quarter of 2022, the first increase in real household income since the first quarter of 2021. Austria had the largest increase as payments associated with the government’s environmental tax reform and cost-of-living assistance boosted household incomes. Inequality in disposable income is high in Chile, Israel, Mexico, Turkey and the United States (OECD Factbook, 2015-2016).

As of 2017, at purchasing power parity, OECD member countries collectively accounted for 62.2% ($39.6 trillion) of global nominal GDP and 32.8% ($53.2 trillion) of global GDP. In the 2000-2010 period, the average economic growth rate in OECD countries was 2.35%. In Figure 3.1 presents the annual change GDP (total, million US dollars) and GDP growth (%) data of OECD countries between 1990 and 2019, which is the year range used in this thesis

Note: Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2010 U.S. dollars

Figure 3. 1 OECD members GDP Growth Rate 1990-2019
Source: World Bank, Retrieved from https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=OE

The annual growth rate of OECD countries is given in Figure 3.1 based on Worldbank data. The growth rates of OECD countries in the 2000s are lower than their levels in the 1990s. Especially in 2008 the effects of the global crisis caused a dip in the growth data, but a recovery is observed as of 2010. OECD members GDP growth rate for 2019 was 1.74%, a 0.61% decline from 2018. GDP growth rate for 2018 was 2.35%, a 0.14% decline from 2017.

Tangible and intangible assets are the most important assets, which determine their value, that are included in the balance sheets of businesses. With the impact of the knowledge-based economy, intangible assets of businesses, have become more important. The best example of this situation is OECD countries. In recent years, expenditures on physical assets in OECD countries have decreased compared to expenditures on intangible assets. In OECD countries, investment in intangible assets amount to about 10% of GDP (WIPO, 2008). According to the OECD 2019 edition of Innovation Indicators, public support for innovation is mostly concentrated among firms that carry out R&D. In the average OECD country, 36% of R&D performing firms and 13% of non-R&D performing firms that undertake other types of innovation activities receive public support for innovation. R&D expenditures of the member countries of the OECD are approximately 772 billion USD. R&D expenditure of the OECD countries increased by 2.2% since 2001 (OECD/Eurostat, 2018). 96 of all triadic patent families are invented in OECD countries in 2009s (OECD Factbook, 2013).

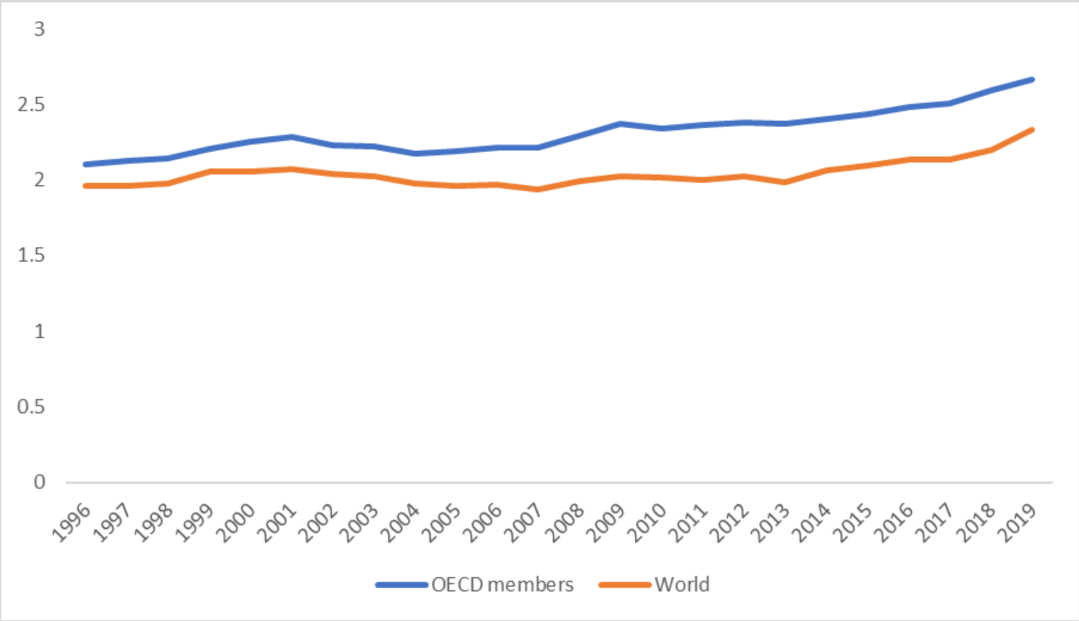


Figure 3. 2 R&D Expenditure (% of GDP) in OECD, 1990-2019
Source: World Bank, Retrieved from https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS, Accessed October 24, 2022.

According to Figure 3.2, in the period between 1996 and 2019, R&D expenditures in OECD countries were above the world average. Since 1999, with an average annual growth rate of 10%, real R&D expenditure has been growing the fastest in Estonia, Portugal, Turkey and Korea. OECD "Main Science and Technology Indicators" (MSTI) (2019) shows that R&D intensity[15] in the OECD area rose slightly from 2.34% in 2016 to 2.37% in 2017. R&D intensity in the OECD area rose from

[15] Expenditure on R&D as a percentage of, GDP

2.37% in 2017 to 2.40% in 2018. According to the data published in the OECD MSTI database, R&D expenditure in the OECD area grew by 1.8% in real terms in 2020.

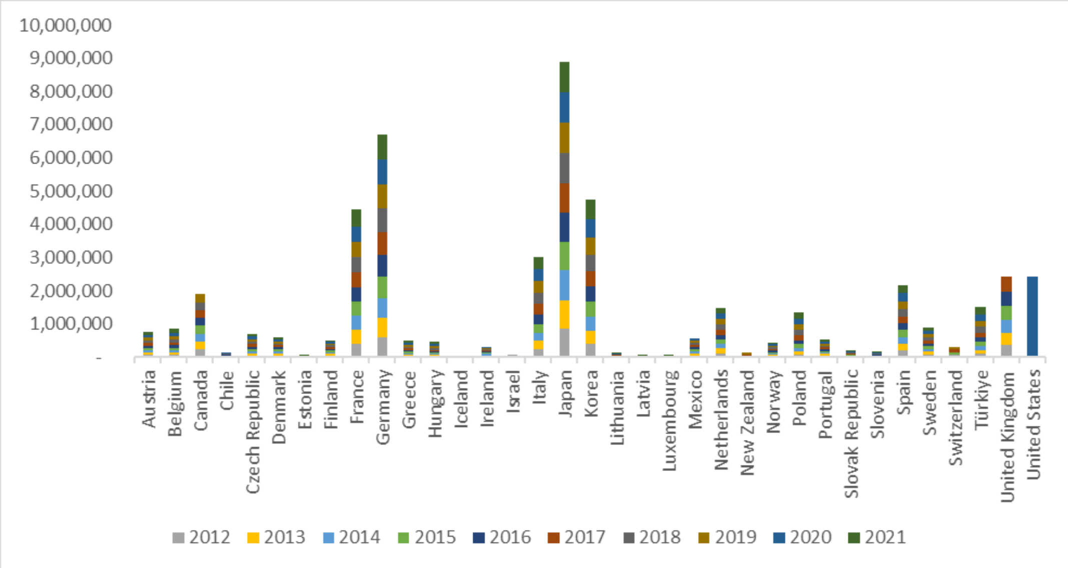


Figure 3. 3 Number of R&D Personnel in OECD Countries, 2012-2021
Source: OECD.Stat, Retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=PERS_FUNC, Data extracted on 04 Jul 2023.

Researchers and other R&D personnel constitute a vital input to R&D performance. In OECD countries, labour costs account for half of the R&D expenditure on average. Two thirds of total R&D personnel in OECD countries consist of researchers. Researchers are "professionals engaged in the conception and creation of new knowledge, products, processes, methods and systems, as well as those who are directly involved in the management of projects for such purposes." Other categories of R&D personnel are technicians who participate in R&D by performing scientific and technical tasks, and other supporting staff (OECD/Eurostat, 2018). The number of researchers employed has increased steadily in recent years. "The OECD Patent Statistics Manual" (2009) report states that approximately 4.2 million people were employed as researchers in 2007 (OECD, 2009). Japan has the highest number of R&D personnel among OECD countries between 2012 and 2021 as shown in Figure 3.3. Germany follows Japan in second place. The number and share of researchers has risen between 2005 and 2015 in most countries, though the share of researchers in total R&D personnel varies widely: from over 80% in Israel, korea, the Slovak Republic, Sweden, and Portugal to 49% in Italy and 43% in China (OECD, 2017). R&D

personnel in all sectors together accounted for more than 2.0 % of the total employment in Belgium, Sweden, Finland, Denmark and Austria in 2021.

Acemoğlu (2006) shows that R&D intensity tends to be higher in countries close to the technological frontier. When a country's economy gets closer to the technological frontier, R&D intensity increases in all industries (Acemoğlu, Aghion, & Zilibotti, 2006). Various sectoral classifications have come to the agenda due to the use of knowledge and technology by different sectors at different intensities and in different ways. In the classification made by the OECD, four different sectoral groups are defined for the manufacturing industry, taking into account the R&D intensity in the sectors: High-technology, medium-high-technology, medium-low-technology and low-technology industries. Examples of high-technology industries are aircraft, spacecraft, and pharmaceuticals. High-technology group includes products such as spaceships, computer and office machines, electrical equipment, medical devices, scientific devices and weapons. The medium-high-technology group includes sectors such as vocational, scientific and measuring devices, vehicles, electrical and non-electrical machines and chemicals excluding pharmaceuticals. Tire and plastic products, iron and steel, metal goods, non-metallic minerals, oil refineries, etc. while the sectors are in the medium-low-technology group. The low-technology group consists of traditional industrial products such as textiles and clothing, food products, beverages and tobacco (OECD, 2011). Having high-tech sectors contributes to the development of the country's economy by enabling the development of exports with high added value. The development of advanced technology constitutes the driving force of economic development and growth, especially for countries that implement an export-oriented growth strategy. According to the report, which compares countries' technology industries and patent portfolios, high-tech industries accounted for 50% of patents filed under the PCT in 2003 and 2005, while medium-high technology industries accounted for 35% (Compendium of Patent Statistics, 2008). Although almost all technology areas experienced growth in patenting over the 1990s, biotechnology and information and communication technologies (ICT) contributed greatly to the overall increase in patenting. The growth in these two major sectors continued in the following years. The share of biotechnology in EPO filings increased from 4.3% in 1994 to 5.5% in 2001, while the share of ICT increased from 28% in 1994 to 35% in 2001 (OECD, 2009). Seven regions of the US, the two regions of Japan, and Denmark are in the top 10 countries in biotechnology patenting

(Compendium of Patent Statistics, 2008). In addition to these statistical information, the view that the economic growth of high technology exporting countries is faster than other countries is dominant in the literature (Lee & Hong, 2010).

3.3.2 Patent Statistics and Patent Policies in the OECD

Patent statistics are used to measure the creativity of countries, regions, firms or individual inventors, with the view that patents are a reflection of creative output and more patents mean more inventions. They are used to monitor the patent system itself. They are also used to the dynamics of the competition process and/or map certain aspects of the innovation process. Patents are useful for monitoring globalisation patterns of countries and country groups. Patent statistics are used to explain the factors that ensure economic growth. Patent indicators, along with other science and technology indicators, contribute to our analyzing of the innovation system. Patent indicators should be interpreted carefully, as each country's patent laws and firms' patenting strategy are different. Patents allow technology to circulate, from inventors to users who can contract a licence, allowing for instance the emergence of companies specialised in inventive activities. Patents are increasingly used for raising capital and liquidity, which in turn facilitates innovation. Although the OECD has no ongoing or planned work program on IPRs at the intersection of competition and IP issues, the Competition Committee occasionally organizes roundtables in this area. The OECD's patent activity is not limited to the generation of patent indicators; efforts are also undertaken to establish methodology and procedures for gathering and evaluating patent indicators, as well as to improve user access to such information (Compendium of Patent Statistics, 2008). For example, the OECD has developed triadic patent families, which are designed to capture all important inventions and to be internationally comparable (OECD Factbook, 2013). Differences in the economic size and structure of countries lead to differences in patent activity. Differences in patent activity are due to differences between countries in variables such as population, R&D expenditures, and GDP (World Intellectual Property Indicators, 2022).

The World Bank assigns the world’s economies to four income groups as low, lower-middle, upper-middle and high income. The classifications are updated each year on July 1 and are based on the gross national income (GNI) per capita of the previous year. In the country classification by income, among OECD countries Colombia, Costa Rica, Mexico and Turkey are in the upper-middle income group, and

34 countries other than these are in the high income group. Patent applications datas are provided by income group of all world countries in Figure 3.4.

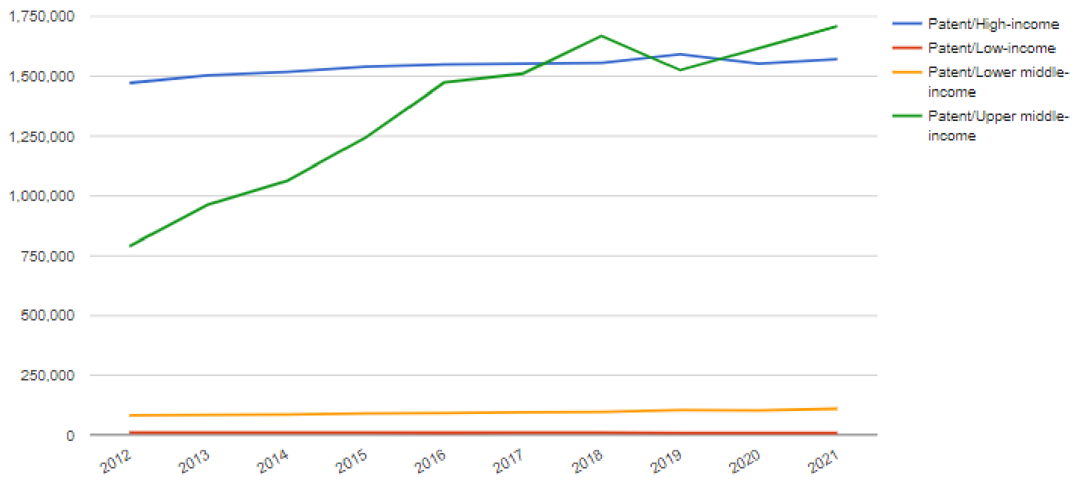
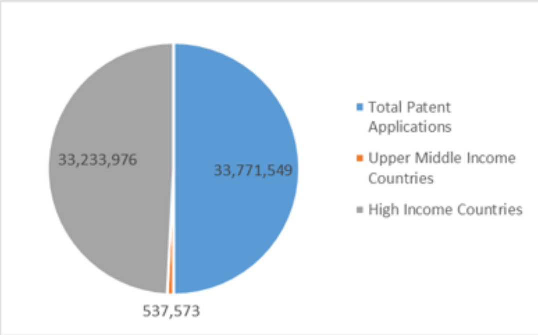


Figure 3. 4 Patent Applications by Income Groups 2012-2021
Source: WIPO Statistics Database, Retrieved from https://www3.wipo.int/ipstats/, June 2023

Figure 3.4 presents that patent applications from countries in the high income category are at the highest level among the given years. However, between 2012 and 2016, patent applications from countries in the upper middle income category showed a rapid increase, surpassing the number of applications made in the high income category, first in 2018 and then in 2020. Among the given years, patent applications from low-income and lower-middle income countries are almost nonexistent. The graph of both income group and patent application and patent granted data in OECD countries between 1990-2019 is given in Figure 3.5.



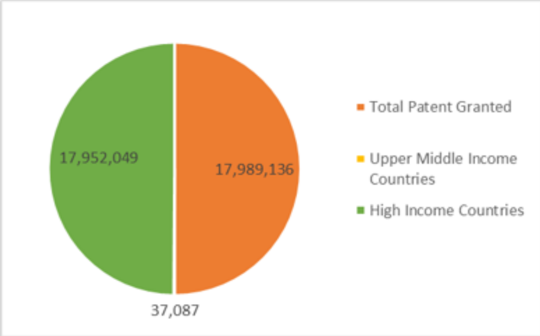


Figure 3. 5 Patent Applications and Patent Granted by Income Groups in OECD Countries 1990-2019
Source: Author's calculation based on WIPO statistics, Retrieved from https://www3.wipo.int/ipstats/index.htm?tab=patent, June 2023

It is seen that between 1990 and 2019, patent applications in upper-middle income OECD countries were realized as 2% of the applications of high income countries on average in Figure 3.5. It is also seen that the number of patents granted in upper-middle income OECD countries is on average 0.18% of the applications of high income countries. In summary, almost all patent applications and patents granted were filed by countries in the high income category. In the given 30 years, 53% of patent applications were granted. The increase in worldwide filings led to 1.7 million patents being granted in 2021, which represents 10% annual growth – the highest for a decade.

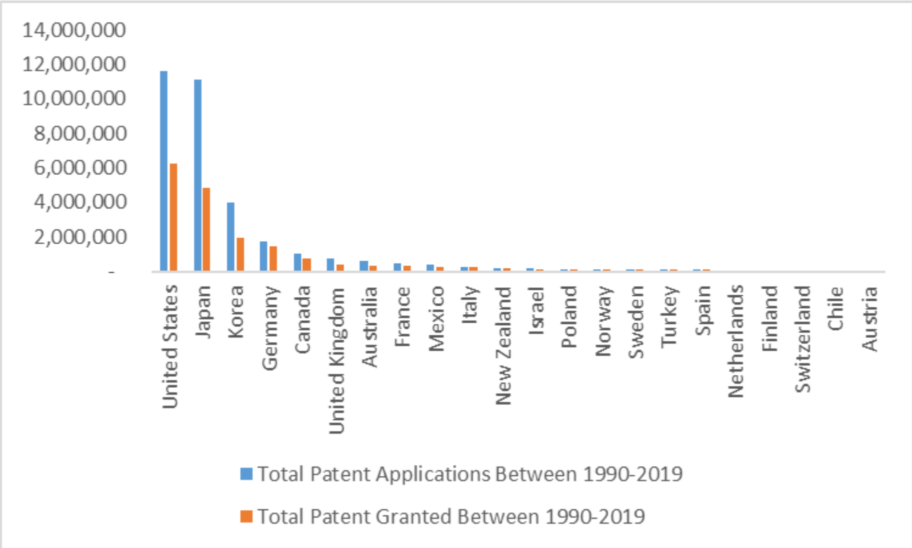


Figure 3. 6 Patent Statistics in the OECD, 1990-2019

Source: Author's calculation based on WIPO statistics, Retrieved from https://www3.wipo.int/ipstats/index.htm?tab=patent, June 2023

The patent statistics of all OECD countries in the relevant year range are shown in Figure 3.6. The US has the highest number of patent applications and patent grants between 1990 and 2019. It is followed by Japan, Korea, Germany and Canada, respectively. After patenting increase in the 1990s, in the early 2000s the increase in patent applications slowed at most patent offices. (Compendium of Patent Statistics, 2008). Triadic patent applications were approximately 49 thousand in 2010. Compared to the 45 thousand patent applicantions recorded in 2000, this number appears that to have a lower rate of increase. Korea's share in triadic patent families, which showed the most dramatic growth, increased to 4.4% in 2010 (1.6% in 2000) (Compendium of Patent Statistics, 2008). When triadic patent families are analyzed by total population, the four most creative countries in 2010 were Japan, Switzerland, Sweden and Germany. Ratios for Austria, Denmark, Finland, Israel, Korea, Netherlands and the US are also above the OECD average (OECD Factbook, 2013).

There has been a high increase in the total number of international patent applications made under PCT in recent years. In 2021, the EPO received 188.600 applications, the highest number to date. In 2020, 275,900 international PCT applications were made. It took 18 years to reach 250 thousand applications and only 4 years for it to double. The WIPO reports that 3.4 million patent applications were made in 2021, the highest annual total ever recorded. This reveals that the given importance to patents in recent years.

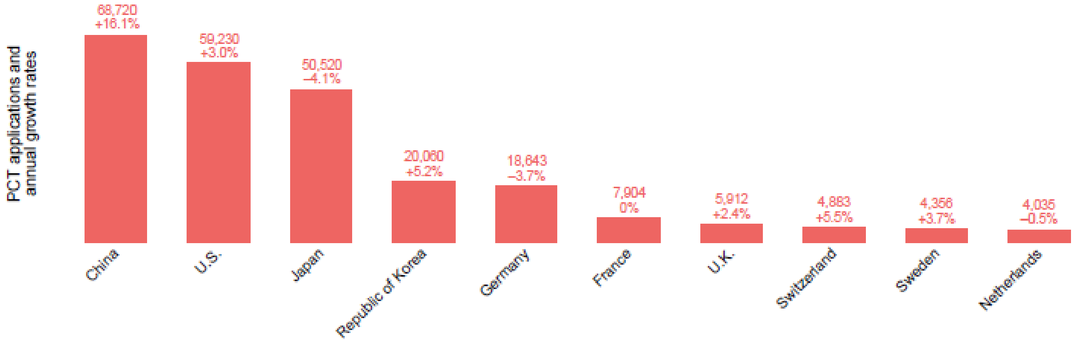
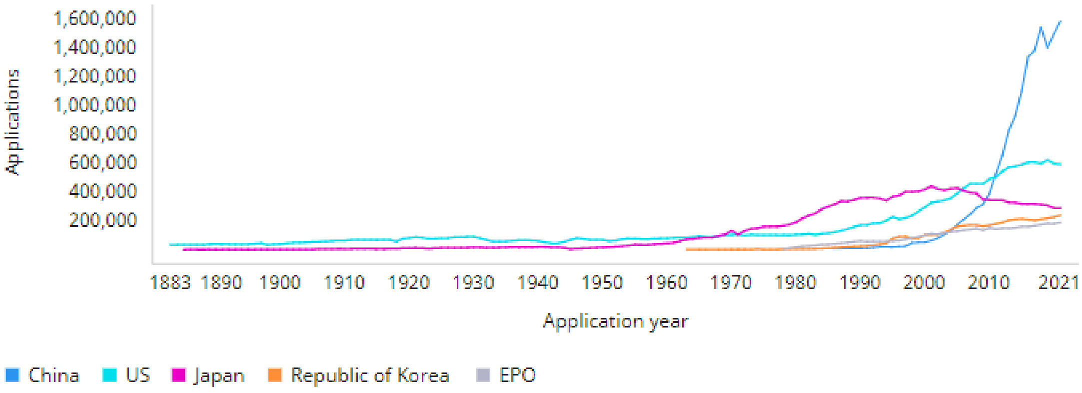


Figure 3. 7 PCT Applications for the Top 10 Origins, 2020
Source: WIPO Statistics Database, Retrieved from https://www3.wipo.int/ipstats/ March 2021.

Figure 3.7 shows that China was the top applicant in 2020 with 68,720 PCT applications. In second and third place are the United States and Japan, respectively. In 2020, the top five countries receiving the most PCT applications accounted for 78.7% of all PCT applications (WIPO, 2021). In 2022, PCT filings rose by 0.3% over 2021. Thus the highest number of PCT applications recorded in a year, 278,100, was reached in 2022. In 2022, China remains the largest origin of PCT applications with 70,015 applications. The US is again in second place with 59,056 applications. Japan held third, the Republic of Korea fourth and Germany fifth rankings (WIPO PCT Newsletter, 2023). Considering these datas, the top five countries with the highest number of PCT applications are China, the US, Japan, Korea and Germany.



Note: Top five offices were selected based on their 2021 totals.

Figure 3. 8 Trend in Patent Applications for the Top Five Offices, 1883–2021
Source: WIPO Statistics Database, Retrieved from https://www3.wipo.int/ipstats/ September 2022.

Globally, patent applications have increased from 1 million in 1995 to 2 million in 2010 and then 3 million in 2016. Figure 3.8 shows that Japan, one of the top five patent offices with the most applications between 1883 and 2021, overtook the US in 1968 and overtook the top position until 2005. Since the early 2000s, however, China has been the country receiving the most applications worldwide. In the total share of the world's top five patent offices have increased by 6.6% from 2011 to 2021 (World Intellectual Property Indicators, 2022). The US, Japan and the EU demonstrate creative performance, contributing to almost 90% of total triadic patent families in 2005 (OECD, 2003c). By the end of 2021, the top ten countries with the most international patent applications are given in Figure 3.9.

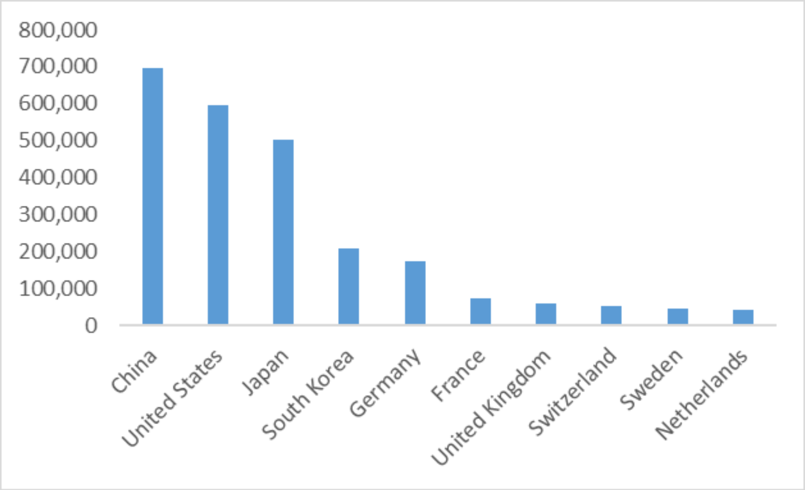


Figure 3. 9 Country and Approximate Number of Patent Applications, 2021
Source: WIPO Statistics Database, Retrieved from https://www3.wipo.int/ipstats/ September 2021.

Figure 3.9 shows that China leads the world in the average number of patent applications in 2021. Japan has the highest rate of patent family per population. Patenting activities appear to be concentrated in some countries such as the US, Japan, Korea, Germany and France (Compendium of Patent Statistics, 2008).

International patent offices allow patent applications to be filed in countries other than the country of residence. In this regard, patent statistics are divided according to the country of residence of the applicant. "A patent application made by an applicant residing in another country or region to the patent office of a particular country or region is called a non-resident application." "A patent application made to an IP office by an applicant residing in the country or region over which that office has jurisdiction is called a resident application."

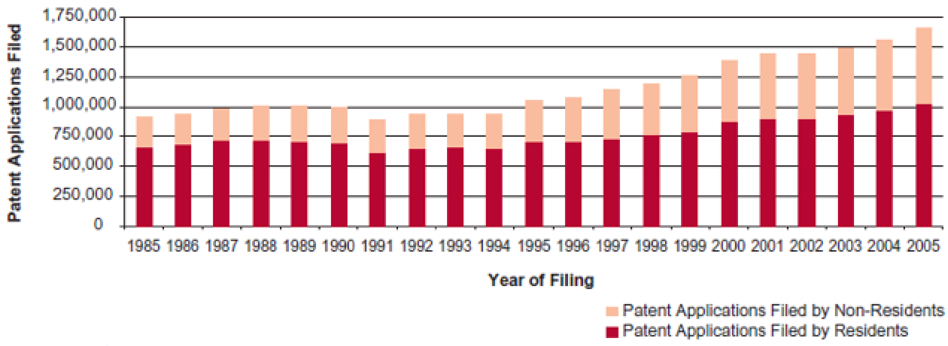


Figure 3. 10 Worldwide Patent Filings by Year of Filing
Source: WIPO Statistics Database, Retrieved from https://www3.wipo.int/ipstats/ September 2021.

According to Figure 3.10, which shows the number of worldwide patent applications filed by residents and non-residents, approximately 1,660,000 patent applications were filed in 2005. Since 1995, patent applications filed by non-residents have increased by an average annual rate of 7.6%. The average annual rate of increase in total patent applications is 4.7%.

On the other hand, PCT applications are also divided according to sectors. In 2021, the business sector accounted for 87.1% of all published PCT applications, followed by the university sector individuals and the government and public research organization sector. Among OECD countries, patents are also dominated by the private sector. Between 2003 and 2005, around 80% of patents belonged to the business enterprise sector (Compendium of Patent Statistics, 2008). In 2021, the fastest growth was seen in the pharmaceuticals sector. It was followed by biotechnology, computer technology and digital communications (WIPO, 2022).

Presented with various figures and statistics, the increase in patent applications, especially in recent years, has also increased the workload of patent offices. Patent offices process applications in a timely manner and maintain a high level of quality has been a matter of debate. Therefore, with regard to patents, there is ongoing debate on three issues: The functioning of the patent system, the importance of patents as a policy tool to promote economic development, and the use of the patent system by developed and developing countries (WIPO, 2008).

Using patents for economic development requires a strong patent policy. Importance of patent and needs for specific policies for patent has been recognized by the policy makers during early 1990s. As a result, by encouraging investment in the

R&D sector, policy makers have recognized that the patent system is an essential element of institutional infrastructure. As a private and intangible good, patents prevent free-riding competition, promote innovation-based competition through limited monopoly and the public interest through disclosure of innovation. Therefore, it can be concluded that the patent system offers an appropriate balance between two policies, private and public interest. In addition to accelerating the growth in innovation, patents also assist to determine the direction of technical change, leading to the adoption of necessary patent policies in countries where such practices are absent (Moser, 2005).

3.3.3 Patent Organizations

A national patent system in which property rights are granted consists of three elements: The legal framework and instruments set out in the laws on the books that define and enable the formal protection of patents in a country; the processes that enforce these rights in practice; and the effective governance and activities of public and private organizations involved in the operations of the patent system (Gowers, 2006). A patent office is a governmental or intergovernmental organization which controls the issue of patents. In other words, patent offices are government bodies that may grant a patent or reject the patent application based on whether the application fulfils the requirements for patentability.

Patent offices grant patents to inventions that meet the patentability criteria of utility, novelty, and non-obviousness (Encaoua, Guellec, & Martinez, 2006). A patent is granted by a national patent office or by a regional office. Currently, the following regional patent offices are in operation: "African Intellectual Property Organization (OAPI), African Regional Intellectual Property Organization (ARIPO), Eurasian Patent Organization (EAPO), European Patent Office (EPO), Patent Office of the Cooperation Council for the Arab States of the Gulf (GCC Patent Office)." In filing applications with these regional offices, the applicant requests protection for his invention in member countries (one or more members) of that regional organization. The regional office has the same patenting criteria as national applications. Therefore, patent applications filed are expected to meet these patenting criterias (WIPO IP Portal, 2023).

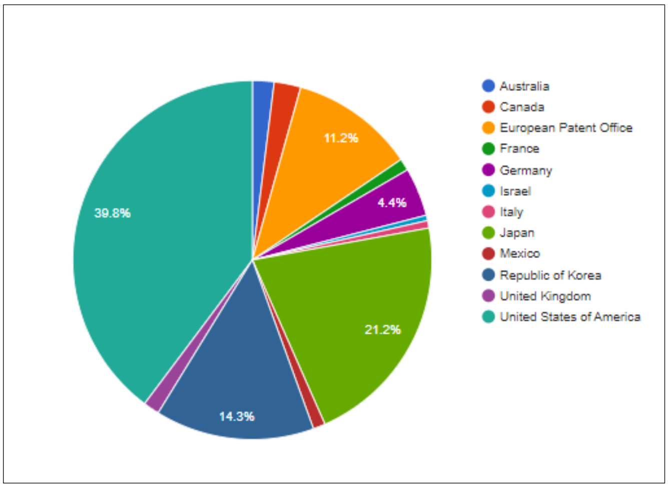


Figure 3. 11 Patent Applications to the Top 20 Offices, 2012-2021
Source: WIPO statistics database. Last updated: February 2023

The distribution of patent applications made to the top 20 patent offices between 2012 and 2021 is shown in Figure 3.11. According to WIPO database in 2021, China's IP office received around 1.59 million patent applications. It was followed by the offices of the US, Japan, the Republic of Korea and the EPO. The top 10 offices accounted for 91.6% of the world total in 2021. More than 85% of all patent filings in 2021 occurred in the IP offices of China, the US, Japan, the Republic of Korea and the EPO (WIPO IP Portal, 2023).

Nowadays, there are three major patent offices on the international platform. The largest of these is the USPTO, which has a fast and cheap processing strategy. The second is the EPO, which follows the reverse strategy and operates with a slower and more costly process. In general; while the USPTO has a low-medium quality review process, the EPO works on the basis of medium-high quality review by conducting detailed analysis. The third major patent office is the Japan Patent Office (JPO), which operates with the examination process and procedures between the strategies employed by the other two patent offices (Picard & Potterie, 2011).

USPTO is the federal agency that grants patents, registers trademarks, and advises the administration, through the Secretary of Commerce, on IP policy. A patent for an invention represents the granting of a property right to the inventor by the USPTO. Generally, "the term of a new patent is 20 years from the date on which the application for the patent was filed in the United States" (USPTO, 2022). The USPTO cooperates with the EPO and the JPO as one of the *trilateral patent offices*. The USPTO is also a receiving office, an "International Searching Authority" and an

“International Preliminary Examination Authority” for international patent applications filed in accordance with the PCT on July 31, 1790. The first U.S. patent was issued to Samuel Hopkins for an improvement “in the making of Pot ash and Pearl ash by a new apparatus and process.” This patent was signed by then President George Washington (USPTO, 2022). The patent application rate of increase in USPTO, which reached 9% per year in the end of the 1980s, slowed in the early 1990s. However, it increased again in the end of the 1990s and reached a 10% annual growth rate.

“The International Patent Institute” established by a group of European countries in the Hague in 1947, makes an important contribution to the internationalization of the patent protection system. The establishment purpose of the institute is to create a common source and archiving system for patent research. The Institute was handed over to EPO with its entire existence in 1978. Established in 1977, the EPO is the executive body of the European Patent Organization established under the European Patent Convention. EPO, headquartered in Munich and responsible for the correct and fast functioning of the European patent system, accepted its first patent application on 1 June 1978. The EPO also has the right to propose certain legal and administrative measures to ensure the smooth operation of the system. It is possible to win the European patent granted by the EPO to new inventions in one or all of the member countries with a single application form. Through the EPO it is possible within the EU to apply for a so-called European patent, but this is in essence a bundle of national patents. The application must be filed with the EPO in one of the office's three working languages, English, French or German and must designate those countries within Europe where protection is wanted. In addition to 27 EU member states[16], EPO has a total of 34 members, including Croatia, Iceland, Liechtenstein, Monaco, Norway, Switzerland and Turkey. By making bilateral agreements with Albania, Bosnia-Herzegovina, Serbia, Montenegro and Macedonia, which are not parties to the Convention, the protection provided by the European patent has become valid in these countries as well (Şehirali, 1998).

Japan Patent Office the industrial property rights system is designed to protect intellectual creations, such as inventions, designs and trademarks, to ensure their

[16] Germany, Avustria, Belgium, Bulgaria, Czechsia, Denmark, Estonia, Finland, France, GCA, Croatia, Holland, Ireland, Spain, Sweden, Italy, Latvia, Litvania, Luksembourg, Hungary, Malta, Poland, Portugal, Romania, Slovakia, Slovenia, Greece.

effective use, and to contribute to industrial development (JPO, 2011). The JPO is located in Kasumigaseki, Chiyoda, Tokyo and is one of the world's largest patent offices. On August 14, 1885, the first Japanese patent was issued. It was to Zuisho Hotta for his formulation of an anticorrosive paint for ship hulls. In 1978, Japan acceded to the Patent Cooperation Treaty. In 1980, the JPO adopted the International Patent Classification, discarding its own patent classification. The JPO is part of the IP5 along with the USPTO, EPO, the Korean Intellectual Property Office (KIPO), and China's State Intellectual Property Office (SIPO). IP5 is a forum of the five largest IP offices in the world. The JPO, SIPO and KIPO are referred to as *Asian Trilateral Offices*. While EPO and USPTO filings correspond to the total number of applications, JPO filings correspond to the total number of claims per application multiplied by total number of applications.

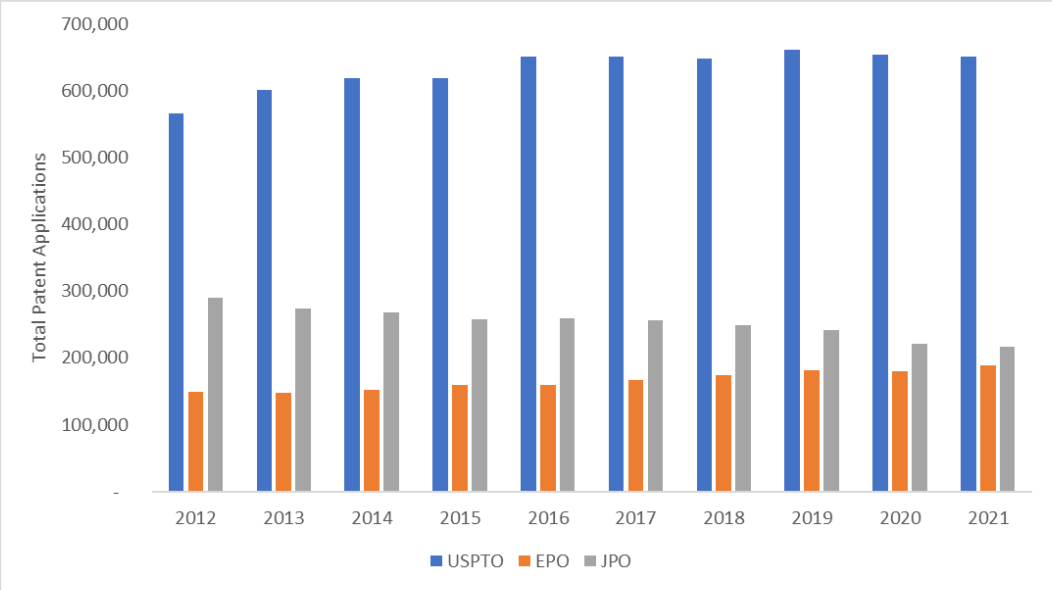


Figure 3. 12 Total Patent Applications Filings at USPTO, EPO and JPO
Source: Author's calculation based on USPTO, EPO and JPO statistics. Retrieved from https://www.uspto.gov/, https://www.epo.org/, https://www.jpo.go.jp/.

Figure 3.12 shows that the total patent applications at JPO was not as high as at EPO or USPTO in those years. However, the number of patent applications is still high compared to the EPO. The patent office that receives the most applications in all years is the USPTO.

"Patents registered by the European Patent Office, the United States Patent and Trademark Office, and the Japanese Patent Office, which are the three largest patent offices in the world, are called *triadic patents*." Since the cost of obtaining a patent in all three of these patent offices is high, triadic patents are considered to have high commercial values. Triadic patent families provide a better measure than traditional single office patent indicators, as valuable innovations in a patent are patented simultaneously in all three major patent institutions. For this reason, the number of triadic patents is one of the important indicators used in the evaluation of a country's innovation performance (Rassenfosse & Potterie, 2009). According to OECD data, the number of triadic patents received by the USA is 16.369, the EU 16.328, Japan 11.751, South Korea 503 in 2001. Among European countries, the number of patents filed by inventors from Germany, Finland and Sweden contributed significantly to the rise in EPO filings after 1995 (OECD, 2004).

Empirical studies have been conducted on the role of the patent system in economic growth. These studies have tried to reach clear insights into that patents and patent systems encourage R&D activities, innovation and technology transfer. Besides empirical studies, statistics also prove the growth of patent demand. Since the mid-1990s, there has been an increase in patent applications filed worldwide, both under the PCT international system and national systems (WIPO, 2008). Within Europe national patent law has become harmonised over time and in 1973 all EU member states signed the European Patent Convention (Munich Convention) which established the EPO and a single procedure for granting patents. The Munich Convention, however, is not a community but an intergovernmental regime. Similarly, at an international level the PCT was agreed in 1970 and has been ratified by 100 countries, including all those of the developed world. With international conventions and patent offices, it is aimed to centralize access, simplify procedures and streamline processes in a single request for an international patent.

CHAPTER 4

4. RELATIONSHIP BETWEEN PATENT AND ECONOMIC GROWTH IN OECD COUNTRIES: PANEL VAR ANALYSIS

The relationship between patent data and economic growth in OECD countries between 1990 and 2019 will be analyzed by panel VAR and Granger causality analyses in this section. The study aims to analyze the causality between patents and economic growth and its direction in 38 OECD countries using patent data which are frequently accepted and used as innovation indicators in the literature. Important studies in the literature related to the thesis topic are summarized, and then the methodology is presented. Then, the findings of all steps of the analysis are presented. The chapter concludes with discussions on the findings of the analysis.

4.1 Emprical Literature Review

The relationship between innovation and economic growth has been a frequent subject of academic studies. According to Stokey (1995), R&D is the sum total of innovation activities. As a result of R&D activities carried out by researchers and scientists, new ideas and inventions emerge. The new inventions that emerge create patents. It is difficult to measure the innovative output of an industry. A variety of data is available, such as R&D spending, patenting, the technological balance of payments, machinery imports, and diffusion. Most researchers use R&D spending as a innovation measure due to the ease of access to R&D data (Stokey, 1995). In academic researchs conducted in recent years, the use of patent data as an indicator of innovation has increased, and the patenting behavior of firms has been discussed more in various aspects (Cantner & Malerba, 2006). It is thought that pioneering studies in the field of patent economics started with the work of Schmookler (1957), Nelson (1959), Arrow (1962) and Scherer (1965). In the literature, there are studies examining the relationship between the number of patent applications and economic growth. In most of these studies, the effects of patents on economic growth were examined by including R&D expenditures. It is generally accepted in the literature that R&D expenditures increase economic growth (Luh & Chang, 1997) (Griliches, 1998) (Freire-Seren, 2001). However, the existence of a relationship between these two variables could not be confirmed in some studies (Aghion & Howitt, 1992) (Sylwester, 2001) (Samimi & Alerasoul, 2009). Various studies investigate the relationship between R&D expenditures, patent applications, innovation, protection of patent rights, IPRs and economic growth for different countries, country groups and years in the literature. For this reason, these studies in the literature are presented by topic, namely R&D, innovation, IPRs and patent, respectively.

Pakes and Griliches (1984) found that R&D expenditures are statistically significant on patent applications in their study, in which they used patent and R&D data from 121 American companies for the period 1968 and 1975. On the other hand, they concluded that when the lagged value of R&D is between 1 and 5, the effect of R&D on patent applications is negative. Hall, Griliches and Hausman (1986) tested the effect of current R&D and lagged R&D values on patents by using patents and R&D data of 642 American companies between 1975 and 1979. According to the econometric analysis results, while the effect of R&D on the patent is simultaneous and strong, the effect of lagged R&D activities on the patent is low. Bassanini and Scarpetta (2001) tested the relationship between R&D expenditures and economic growth with samples from 21 OECD countries covering the period 1971-98. Using panel data analysis, they found that R&D expenditures have a positive and significant effect on the economic growth rate. Sylwester (2001) examined the relationship between R&D expenditures and economic growth using multivariate regression for two different country groups and found a positive relationship between these two variables in G7 countries. However, the relevant relationship was not significant in the OECD countries. Özer and Çiftçi (2009) investigated the impact of R&D expenditures, number of patents and researchers on growth with three different models using the panel OLS method. They concluded that all three variables have a positive impact on growth. Prodan (2005) examined whether the number of patent applications in selected OECD countries between 1981 and 2001 depends on private sector R&D expenditures.

The study showed that there is a positive relationship between R&D expenditures and the number of patent applications. Horvath (2011) examined the effect of R&D on economic growth in the long run, using data from 1960 and 1992. He concluded that R&D increases long-term growth in his analysis with Bayesian model averaging. Mercan et al. (2011) conducted a study covering the years 2003-08 for 25 countries. The relationship between the number of patent approvals from the EPO, entrepreneurial ratios, public, private and higher education sector R&D expenditures and the number of researchers in these sectors was tested with panel data analysis. While the effect of R&D expenditures made by the private sector and higher education on the number of patents is positive, the effect of R&D expenditures made by the public sector on the number of patents is found to be negative. Gülmez and Yardımcıoğlu (2012) analyzed the long-term relationship between R&D expenditures and economic growth using 1990 and 2010 data for OECD countries with panel data method. It was concluded that there is a mutual and significant relationship between these two variables in the long run. Özcan and Arı (2014) examined the relationship between R&D expenditures and economic growth using 1990 and 2012 data for 15 selected OECD countries. They stated that innovation activities should be supported and the share of innovation expenditures in GDP should be increased. Freimane and Balina (2016) examined the empirical relationship between R&D expenditures and economic growth in EU countries during the period of 2000 and 2013. The results show that R&D expenditures have a statistically significant on economic growth. Türedi (2016) investigated the causality relationship between economic growth, R&D expenditures, and patent applications in the 1996 and 2011 period for 23 OECD countries using the Generalized Method of Moments (GMM) approach. The study concludes that there is a two-way relationship between R&D expenditures and growth, there is one-way positive causality between patent applications and growth. Türedi determined that the direction of causality is from patent applications to economic growth. Türkmen (2019) examined the relationship between R&D expenditures and economic growth using 1991 and 2016 data for 20 OECD countries in his study. It concludes that the relationship between these two variables is positive.

Cameron (1996) had explored empirical evidence for the relationship between innovation and economic growth. It examined technological diffusion among companies, industries and countries, taking into account different innovation measures such as R&D expenditure, patenting and innovation counts. It was concluded that innovation contributed significantly to growth. Crosby (2000) investigated the importance of patent data used as an innovation indicator in the growth of the Australian economy in the period 1991 and 1997 by using a VAR model. In the study, patent applications were used as the independent variable and real GDP and labor productivity as the dependent variables. It is found that patent applications positively affect real GDP and labor productivity in the long run. It has been determined that a 1% increase in patent applications (innovation) leads to an increase of 0.36% in real GDP and 0.14% in GDP per employee in the long run. On the other hand, there is negative relationship between patents and growth in the short-run. Ülkü (2004) tested the relationship between patent applications, R&D expenditures and economic growth with a data set covering the period 1981-97 for 20 OECD and 10 non-OECD countries using GMM method. According to the results of the study, there is a strong and positive relationship between innovation and national income per capita in both OECD and non-OECD countries. Wu (2010) analyzed the contribution of R&D activities to innovation and economic growth in China. The study concludes that if R&D intensity has a positive effect on regional innovation, innovation affects economic growth positively. Hu and Ipl (2012) anayzed the relationship between patent protection, innovation and economic growth using panel data analysis for the period 1981 and 2000 and 54 companies. The findings showed that strict patent protection in patent-oriented industries is high and leads to economic growth. Gross national product per capita also increases. Gülmez and Akpolat (2014) examined the relationship between innovation and economic growth for 15 OECD countries covering the period 2000-10 period using the GMM method. They found that R&D expenditures and the number of patents has a positive effect on economic growth. According to the results of the study, 10% raise in patent expenditure increases GDP by 0.77%. They concluded that R&D expenditures increase GDP four times more than patents.

There are relatively few papers have modeled the dynamic effects of IPRs and growth. Segerstrom (1991) analyzed a dynamic general equilibrium model using research and development activities and patent protection. Segerstrom emphasized that technological change resulting from R&D activity is affected by the length of patent term and that the length of patent term has a slowing effect on innovation and economic growth. Kanwar and Evenson (2003) analyzed IPR and R&D expenditure datas for 32 countries. As a result of this analysis, it was concluded that stronger IPRs have a positive impact on R&D investments. Chen and Puttitanum (2005) analyzed the impact of IPRs on innovation in 63 developing countries. While the results of the study show that IPRs have a positive impact on innovation, it is also interpreted that there is an u-shaped relationship between IPRs and economic growth.

Bound, Cummins, Griliches, Hall and Jaffe (1984) in their study using patent and R&D data of 2582 American companies, found that not all companies engaged in R&D activities, but only some of them received patents. In addition, they found that there is a strong positive relationship from R&D to patent. Schmookler (1966) argued that there would be a positive relationship between patents and economic growth in the long run. However, the variables might be negatively related to each other in the short run. Devinney (1994) showed that there is a positive relationship between patent and GDP growth rate in the short run. Thompson and Rushing (1996) examined that the relationship between patent protection and economic growth for the period 1970 and 1985 for 112 country groups. The study reveals that there is a strong correlation between the two variables. Besides, the study argued that when R&D activities are protected by patents, they might be a determinant of economic growth. Bilbao-Osorio and Rodríguez-Pose (2004) examined the relationship between the number of patents, economic growth and R&D expenditures for the EU countries in the period of 1990 and 1998 using panel data analysis. The findings show that an increase in the number of patents affected to economic growth positively and significantly. It has been determined that the relationship between the number of patents and economic growth is less strong than the relationship between R&D expenditures and the number of patents. Gurmu and Perez-Sebastian (2008) investigated the relationship between patent and R&D expenditures of firms in the US manufacturing sector for the period 1982 and 1992 using the GMM. The empirical research concludes that the simultaneous relationship between patent and R&D expenditures is quite strong**.** As a result of the study conducted by Hasan and Tucci (2010) it was found that patents have a significant impact on economic growth using data from 58 countries. Josheski and Koteski (2011) investigated the relationship between patents and GDP using the ARDL model and Granger causality test using quarterly data covering the period 1963-1993 in G7 countries. It has been determined that there is a positive relationship between patent and GDP variables in the long run, but there is a negative relationship in the short run. Saini and Jain (2011) examined the impact of patent applications on economic growth in 9 Asian countries[17] over the period 2000 and 2009. While it was concluded that patent applications do not affect GDP in 5 Asian countries[18], it was found that patent applications have a positive impact on growth in the remaining countries of Singapore, Thailand, Japan and Vietnam. In their study based on Turkey, Demir and Geyik (2014) revealed that the low levels of R&D expenditures have a negative impact on the number of patent applications and patenting. Li and Jiang (2016) investigated the contribution of R&D expenditure and patent to China's GDP using Chinese national data from 1995 to 2014. The results showed that both R&D expenditures and number of patents were positively correlated with GDP. However, it is observed that R&D expenditures contribute more to economic growth than the number of patents granted.

In summary, many studies in the literature have focused on the relationship between economic growth and R&D, innovation, IPRs and patents. It has been concluded that countries that provide strong patent protection to innovation and R&D activities have higher economic growth than other countries. These studies have generally used the number of patent applications as an indicator of innovation. There are many studies suggesting that patenting should encourage firms to invest in R&D and innovation. On the other hand, there are also studies arguing that strict patent protection regimes can prevent innovation. However, in general patent policies appear to provide protection. Even, there are studies that reveals the causality relationship between patent applications and economic growth. In this perspective, it can be concluded that patents have a boosting effect on economic growth and patent regimes should be strengthened.

4.2 Research Methodology

In this study on OECD countries, the panel data analysis method is used to analyze the existence and direction of the relationship between patents and economic growth. Patents were distinguished into total number of patent applications (direct and PCT national phase entries) and grants (direct and PCT national phase entries) for the

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[17] India, China, Indonesia, Philippines, Malaysia, Singapore, Thailand, Japan, Vietnam.

[18] India, China, Indonesia, Philippines and Malaysia.

sake of analysis. Since innovation in an economy is a situation that occurs as a result of long periods, the PVAR analysis method, which is based on both current and past year data, was preferred in this study. In the analysis of the study, Pesaran (2004) CD test is first applied to determine the cross-sectional dependence between units. After determining the between cross-sectional dependence, the Pesaran's *Cross-Sectional Augmented Dickey Fuller* (CADF) unit root test, which is one of the second-generation unit root tests, is applied. GMM estimator of panel VAR approach and panel Granger causality test developed by Arellano and Bond (1991) is used for panel VAR and causality analyses.

4.2.1 Panel Time Series Analysis

Three types of data are used in econometric analysis: Time series data, cross section data, and panel data. Panel data is defined as bringing together the cross-sectional observations of the units in a certain period. There are N units in the panel data and T number of observations corresponding to each unit. The method of estimating economic relations with the help of panel data models created with cross-sectional data with time dimension is called panel data analysis (Tatoğlu, 2021).

Compared to cross-sectional or time-series data, it is possible for economists to predict more comprehensive and more realistic models with panel data (Verbeek, 2005). Panel data sets have many advantages in the application of causality tests. The first advantage is that since the panel datasets contain a large number of data, it will allow the use of more lag coefficients, resulting in the relaxation of the stationarity assumption (Holtz-Eakin, Newey, & Rosen, 1988). Another advantage is that the large number of data increases the degree of freedom and reduces the possibility of multicollinearity between the variables (Hsiao, 2003). Thus, the efficiency and reliability of econometric forecasts increase (Tatoğlu, 2020).

The panel data model is expressed as in equation 4.1, as the number of units, i = 1, 2, 3, ..., N, time dimension, t = 1, 2, 3, ..., T.

$$Y_{it} = \alpha_{it} + \beta_{kit} X_{kit} + u_{it} \quad \textbf{(4.1)}$$

Where Y is the dependent variable, X_k is the independent variable, α is the constant parameter, β is the slope parameter, and u is an error term. The fact that the variables and the error term have subindex i and t indicate that they have a panel data set (Tatoğlu, 2021).

4.2.1.1 Panel Cross Sectional Dependence

In studies where panel data analysis is preferred, it is necessary to determine whether all cross-section units in the panel data are equally affected by the shock when the series is shocked (Güriş, 2018). In this regard, the cross-sectional dependence test is performed to see whether a shock affecting a unit will spread to all other units in the panel (Öztürk & Öz, 2016).

There are various tests in the literature such as Breusch-Pagan (1980) LM, Pesaran (2004) CD, Friedman (1937) and Frees (1995, 2003) tests in order to test the existence of inter-unit correlation, that is, cross-sectional dependence. The hypotheses valid for these tests are as follows:

H_0: ρ_{ij} = corr (u_{it}, u_{jt}) = 0, $i \neq j$

H_1: ρ_{ij} = corr (u_{it}, u_{jt}) ≠ 0, $i \neq j$

The null hypothesis is expressed as “There is no cross-sectional dependence”; alternative hypothesis is expressed as “There is cross-sectional dependence” (Tatoğlu, 2021).

Since the unit size is larger than the time dimension[19] in the data set used within the scope of this thesis, the Pesaran (2004) CD Test was used to test the cross-sectional dependence. For this reason, only the descriptions of the CD test will be included in this section.

4.2.1.1.1 Pesaran’s Cross Sectional Dependence Test (Pesaran CD)

One of the statistics that tests the cross-sectional dependence is the Lagrange Multiplier (LM) statistic developed by Breusch and Pagan (1980). Pesaran points out that the scaled LM test statistic shows size distortion for small T_{ij} and the distortion gets worse for larger N's. For this purpose, Pesaran (2004) developed the CD test statistic by considering the size distortion problem (Pesaran, 2004).

[19] In data set which used in this thesis N=38, T=30.

$$CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij} \quad \textbf{(4.2)}$$

The test developed by Breusch and Pagan (1980) is incomplete when N is large. Therefore, Pesaran CD (2004) test is recommended especially for cases where N is large and T is small (Pesaran, 2004). When the probability value to be obtained as a findings from Pesaran-CD (2004) test is less than 0.05, H_0 hypothesis is rejected at 5% significance level. Rejection of the null hypothesis means that there is cross-sectional dependence. 4.2.1.2 Panel Unit Root Tests

It is necessary to know whether the stochastic process changes with time when setting any time series model. Because the non-stationary stochastic process, whose quality changes depending on time, causes false results if expressed with classical regression models (Gujarati, 2003). Econometric analyses with non-stationary series will cause unbiased results from standard t, F tests and R^2 values, resulting in misleading results known as spurious regression (Tatoğlu, 2020). A time series is stationary, converging towards a certain value over time, in other words, it has a constant mean, constant variance and covariance depending on the lag level. Panel unit root tests are examined under two groups as first-generation and second-generation panel unit root tests as a result of the sampling process. While the first-generation tests assume that there is no correlation between the units, the main feature of the second-generation tests is that they allow correlation between the series belonging to the units (Tatoğlu, 2020). The study employs Pesaran CIPS test as the relevant test holds a strength compared to the other tests.

4.2.1.2 Pesaran CIPS Unit Root Test

Pesaran (2007) extended the cross-sectional averages (CA) of the lagged levels and first differences of the individual series by adding them as factors to the Dickey Fuller (DF) or Augmented Dickey Fuller (ADF) regression. This test is named as *Cross-Sectional Augmented Dickey Fuller* (CADF) (Tatoğlu, 2020). The CADF regression used in this test is as follows:

$$\Delta Y_{it} = \alpha_i + \rho_i Y_{it-1} + d_0 \; \overline{Y}_{t-1} + \; d_1 \Delta \; \overline{Y}_t + \; \varepsilon_{it} \quad \textbf{(4.3)}$$

Here in equation 4.3, $\bar{Y}_t$ is the mean value of the horizontal section according to t time. The lagged first differences of both Y_{it} and Y_t are added to the model and the hypotheses of the model are as follows (Baltagi, 2007).

H_0: $\rho_i = 0$ (for all i)

H_1: $\rho_i < 0$ (i=1,2, …, N_i) and $\rho_i = 0$ (i=N_{i+1}, N_{i+2}, …, N)

Cross-section mean and lagged values of Y_{it} are used as instrumental variables for common factors. With the mean value of the t statistics of the delayed variables in the CADF regressions, the CIPS value will be found:

$$\mathrm{CIPS} = \frac{1}{N} + \sum_{i=1}^{N} \mathrm{CADF}_i \quad \textbf{(4.4)}$$

When the probability value (t-bar) to be obtained as a result of the CADF test is less than 0.05, H_0 hypothesis is rejected at 5% significance level. Rejection of the null hypothesis means that research variable is stationary.

4.2.1.3 Panel Vector Autoregressive Regression Models (Panel VAR)

Cross-sectional dependence and unit root tests are prerequisite tests for PVAR analysis. Therefore, these tests are explained before the PVAR. Vector autoregressive models (VAR), developed by Sims (1980), is the generalization of univariate autoregressive models and expressing them as a multivariate model. In these models, multiple variables that are related to each other are handled internally and the dynamic relationships between these variables are modeled simultaneously. In other words, a separate model is established for each variable, and in these models, the lagged values of the variables and the lagged values of other variables are also used (Sims, 1980). The PVAR approach is a technique for panel time series analysis that aims to investigate the dynamic relationship between variables.

The two-equation VAR model can generally be represented as follows (Tatoğlu, 2020):

$$Y_{it} = \alpha_0 + \sum_{l=1}^{m} \alpha_1 Y_{it-1} + \sum_{l=1}^{m} \delta_1 X_{it-1} + \mu_i + u_{it} \quad \textbf{(4.5)}$$

$$X_{it} = \alpha_0 + \sum_{l=1}^{m} \theta_1 Y_{it-j} + \sum_{l=1}^{m} \lambda_1 X_{it-1} + \mu_i + u_{it} \quad \textbf{(4.6)}$$

4.2.1.3.1 Generalized Method of Moments (GMM)

Since the panel VAR is essentially a dynamic model, the GMM method, which can provide the orthogonality condition, is preferred to other estimation methods (Tatoğlu: 2020, 133). This method is used when the error terms are autocorrelated. In addition, it is a suitable method in case of both fixed variance and varying variance (Akay, 2015).

Consistent Model and Moment Selection (MMSC) criteria proposed by Andrews and Lu (2001) are widely used for PVAR model selection criteria. These criteria are based on Hansen J overidentifying restrictions test statistic and make model selection by considering the GMM method used. Andrews and Lu (2001) recommend $MMSC_{BIC}$ or $MMSCI_{HQIC}$ criteria. On the other hand, The $MMSC_{AIC}$ criterion states that this criterion does not meet the consistency conditions, since the probability of choosing asymptotically very few overidentifying restrictions is positive.

4.2.1.3.2 Impulse Response Analysis

In the PVAR analysis method, impulse-response functions are used to measure the effect of a standard deviation shock that may occur in any variable in the model on all other variables, including the variable itself.

4.2.1.3.3 Variance Decomposition

Variance decomposition reveals what percentage of the change in one variable is explained by the change in the other variable. While calculating variance decomposition, action-response functions are used.

4.2.1.3.4 Granger Causality Test

Statistically, causality is the derivation of the predicted future values of a time series variable by being affected by the past values of itself or another related time series variable (Işığıçok, 1994). Causality in the Granger sense is expressed as if having knowledge of the past values of an X variable allows for a more precise prediction of Y, then the variable X is the cause of the Y variable in the Granger sense.

There can be one-way or two-way causality relationship between economic variables from one variable to another. The existence and direction of causality can be tested with the help of causality tests. Granger (1969) developed a test based on Wald statistics to detect the existence of causal relationships between two variables. The first equation of the panel VAR model is as follows:

$$Y_{it} = \alpha_i + \sum_{k=1}^{K} \gamma_k Y_{it-k} + \sum_{k=1}^{K} \beta_k X_{it-k} + \varepsilon_{it} \quad \textbf{(4.7)}$$

The null hypothesis is set up as H_0: β_k= 0 and states that there is no causality from X to Y (Tatoğlu, 2020).

4.3 Panel Data Set and Empirical Model

The study investigates the impact of patents on economic growth and the impact of economic growth on patents. A panel VAR analysis was conducted for a panel of 38 OECD countries between 1990 and 2019. This time period has been chosen for the analysis because patent data statistics for all OECD economies do not go back to the 1990s. OECD countries are a good sample of countries to study the knowledge spillovers because they represent a dominant share of patenting and R&D worldwide. Furthermore, there has been increasing support for private R&D among OECD countries over the last two decades (OECD, 2016).

GDP data with constant prices (in US$) of 2015 were used as explanatory variable and economic growth indicator in the study. In determining the dependent variables used in the empirical analysis, Galindo and Mendez's (2014) study was taken into account because of the phrase it is possible to express innovation with the change in the number of patents (Galindo & Mendez, 2014). Griliches (1998) advocates that patent statistics are a good indicator of innovation activities, as patent numbers show exactly what is happening in the industry (Griliches, 1998). In this context, similar to the studies in the literature, the number of patent applications was used as an innovation indicator in this study. Patent application statistics are generally kept in two categories according to resident and non-residents. Therefore, the total number of patent applications as resident plus non-resident is used as a variable. The fact that the patenting process is not the same between countries creates a problem in the use of patent application numbers in the analysis. Also, the time lag between patent applications and grants can be very long. On the other hand, not all patent applications are accepted. For this reason, in order to strengthen the analysis, the patent granted data was also included in the analysis as a dependent variable. In a limited number of studies in the literature, the relationship between patent granted and economic growth has been discussed. In this respect, the results of the study may present diversified findings for patent applications and grants.

In the panel time series analysis, 38 OECD member countries as of 2021 are used as the country group. These countries are; Austria, Australia, Belgium, Canada, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. Detailed information on dependent and independent variables and data sources are presented in Table 4.1.

Table 4. 1 Variables and Data Sources

Variables	Abbreviation	Source	Unit
Dependent Variable			
Gross Domestic Product	GDP	World Bank	2015 Constant US$
Independent Variable			
Patent Application* (resident + non-resident)	PA	WIPO	Number of patent applications
Patent Grants** (direct and PCT national phase entries, count by applicant's origins)	PG	WIPO	Number of patents granted

* Independent variable which used in Model 1
** Independent variable which used in Model 2

As presented in Table 4.1., the empirical research includes gross domestic product (GDP), patent applications (PA), and patent grants (PG) as variables. While the data for the former variable was collected from World Bank (World Development Indicators), the data for the patent related variables were gathered from World Intellectual Property Organization (WIPO). All the variables in Table 4.1. are expressed in their natural logarithms in the empirical estimation.

4.4 Empirical Findings

The empirical findings presented in this section of the study are analyzed in five steps. In the first step, the data set to be used in the analysis is introduced with descriptive statistics. Then, the cross-sectional dependence of the variables, determined by the Pesaran CD test are presented. In the third stage, the stationarity results of the series analyzed by Pesaran (2007)'s Covariate Augmented Dickey-Fuller second-generation unit root test are indicated. GMM method is used to estimate the PVAR model in the forth step. In the fifth step, the findings of the existence and direction of causality in the variables by Granger causality test are provided. Stata 17 package program is used for all econometric analyses in this study.

The study aims to analyze the two-way relationship (if any) between patents and economic growth and uses the following two research questions: Do patents affect economic growth? Does economic growth generate patents?

In this study, in which the relations between total number of patent applications-economic growth and total patent grants-economic growth are examined, the following two models are estimated.

Model 1a: $\mathrm{lGDP}_{it} = \mathrm{lPA}_{it} + \beta_1 \mathrm{lGDP}_{i(t-1)} + u_{it}$ **(4.8)**

t= 1990, …, 2019, i= Australia, …, US.

Model 1b: $\mathrm{lPA}_{it} = \mathrm{lGDP}_{it} + \beta_1 \mathrm{lPA}_{i(t-1)} + u_{it}$ **(4.9)**

t= 1990, …, 2019, i= Australia, …, US.

Model 2a: $\mathrm{lGDP}_{it} = \mathrm{lPG}_{it} + \beta_1 \mathrm{lGDP}_{i(t-1)} + u_{it}$ **(4.10)**

t= 1990, …, 2019, i= Australia, …, US.

Model 2b: $\mathrm{lPG}_{it} = \mathrm{lGDP}_{it} + \beta_1 \mathrm{lPG}_{i(t-1)} + u_{it}$ **(4.11)**

t= 1990, …, 2019, i= Australia, …, US.

Where GDP is gross domestic product, PA is total patent applications which is the sum of resident and non resident, PG is total patent grants, u is an error term. Besides that i represents OECD countries and t represents the time period between 1990 and 2019. All the variables are expressed in their natural logarithms, as presented with the letter “l” in front of each variable.

Descriptive statistics of GDP, PA and PG variables considered in the study are provided in Table 4.3.

Table 4. 2 Descriptive Summary Statistics

	GDP ($)	PA	PG
Obs	1100	1112	1117
Mean	1.07e+12	30370.1	16103.87
Std. Dev.	2.53e+12	91156.38	37135.3
Min	9.13e+09	22	1
Max	1.99e+13	621353	333012

Table 4.2 shows the summary statistics for the whole panel. The number of observations varies for all variables, and there is a gap between the variables, that is, an unbalanced panel data set is in question. The variables used in the study were included in the analysis in their natural logarithms, since they showed geometric series characteristics, that is, the difference between the minimum and maximum values of the variables was large. The descriptive statistics of the variables lGDP, lPA ve lPG whose logarithms were taken are presented in Table 4.3.

Table 4. 3 Descriptive Summary Statistics

	lGDP ($)	lPA	lPG
Obs	1100	1112	1117
Mean	26.36006	7.9589	7.058001
Std. Dev.	1.578799	2.133073	2.593215
Min	22.9363	3.091033	0
Max	30.6232	13.33982	12.73552

According to Table 4.3., the average gross domestic product of 38 OECD countries between 1990 and 2019 was $2.636,006. The country with the highest GDP in this group of countries and years discussed in the study was US in 2019, and the country with the lowest GDP was Iceland in 1995. According to the patent data obtained from WIPO, the average number of patent applications was 30.370 and the average number of granted patents was 16.103 in the country group examined and during the period. While the most applications were made by the US in 2019, Japan had the highest number of granted patents in 2012.

4.4.1 Findings From Panel Cross Sectional Dependence Test

Causality analysis which is frequently used together with the panel VAR approach, investigates whether the related variables have a causal relationship with each other. Because both are time series analyses, stationary variables must be used in analyses (Tatoğlu, 2020). Accordingly, a preliminary step for these analyses is to apply unit-root tests to check the stationarity of variables. In order to determine which generation unit root test should be applied in panel data analysis, the Pesaran CD Test, which is one of the cross-sectional dependency tests, was applied because the unit size of the model is large in time dimension. The following hypotheses were applied for the CD test in OECD countries, respectively, and the test statistics findings are given in Table 4.4.

H_0: $\rho_{ij=}0$, There is no cross-sectional dependence

H_1: $\rho_{ij}\neq 0$, There is cross-sectional dependence

Table 4. 4 Pesaran's Cross-Sectional Dependence Test

Variable	CD-Test	p-value	corr	abs(corr)
lGDP	131.79	0.000*	0.939	0.939
lPA	2.69	0.007*	0.019	0.327
lPG	86.00	0.000*	0.602	0.668

* donates the significance levels at the 5%.

Table 4.4 shows that the p-value is less than 0.05 for all variables and the hypothesis of 'H_0: There is no cross-sectional dependence in the model.' was rejected according to the CD test statistic. Thus, it can be said that there is cross-sectional dependence at the 0.05 significance level. Because all the variables are cross-sectionally dependent, the study applies second-generation panel unit-root test to test for the stationarity of variables.

4.4.2 Findings from Panel Unit Root Tests

Before making econometric analysis of a time series, it should be checked whether the series is stationary or not. Econometric analyzes with non-stationary series will cause deviated results from standard t, F tests and R^2 values, resulting in misleading results known as spurious regression (Tatoğlu, 2020).

Since the series contain cross-section dependence and the data set used is unbalanced and heterogeneous, the Pesaran CADF test, one of the second-generation unit root tests, was applied in the light of the following hypotheses.

H_0: Contains unit root, series is non-stationary.

H_1: Does not contain unit root, series is stationary.

Table 4.5 presents findings from Pesaran's CADF panel unit-root tests.

Table 4. 5 Pesaran CADF Unit Root Test Results

		Pesaran (2007) Constant		Pesaran (2007) Constant & Trending	
		Z[t-bar]	P-value	Z[t-bar]	P-value
lGDP	Level	3.130	0.999	-2.314	0.010*
	1st difference	-9.171	0.000*	-6.446	0.000*
lPA	Level	-1.104	0.135	-1.294	0.098
	1st difference	-14.170	0.000*	-13.197	0.000*
lPG	Level	-3.802	0.000*	-4.426	0.000*

* donates the significance levels at the 5%.

The findings in Table 4.5. show that the null hypothesis indicating the existence of a unit root is not rejected at the 5% significance level in the model with only constant terms for the IGDP variable. The null hypothesis is rejected at 5% significance level in the model with a constant term trend. Since the probability value is strongly higher than the 0.05 significance level, the IGDP variable is non-stationary at level.

When the unit root test results of the IPA variable are evaluated, it is seen that the null hypothesis is not rejected at the 5% significance level both in the a constant term model and in the model with constant and trend. It is concluded that the IPA variable is not stationary at the level.

The results of the unit root test applied to the levels of the variables, t statistics and probability results, show that the number of patent applications and economic growth variables used in econometric analysis are non-stationary at the level [I(0)]. This means that the series contain unit-root problem. For this reason, the first differences of the lPA and lGDP variables are taken. Pesaran CD test and the Pesaran CADF unit root test were employed for the first difference series. As a result, the number of patent applications and economic growth variables [I(1)] are first order stationary.

When the unit root test findings of the lPG variable are evaluated, it is seen that the null hypothesis is rejected at the 5% significance level both in the model with a constant term and the model with a constant trend. Therefore, the lPG variable is stationary at the level. According to the results of the panel unit root test for the second model, the dependent variable (lGDP) is not stationary at level, while the independent variable (lPG) is stationary at level.

As a result of the second-generation unit root tests, it is concluded that the lPG variable is stationary at the level, while the IPA and lGDP variables are not stationary at level. The first differences of the variables were tested for stationarity by repeating the same steps. Table 4.5 presents that dlPA and dlGDP variables become stationary in the first differences. The rest of this study uses the first differences of lPA and lGDP variables: dlPA and dlGDP to apply the relevant methodologies. The lPG variable itself, which is at a stationary level, is included in the analysis.

4.4.3 Findings from Panel Vector Autoregressive Regression Analyses

An important point to consider when estimating the VAR model is the length of the lag to be used. When lags are set longer than they actually are, variables take on higher values than they actually are. This raises the problem of overparameterization (Katos, Lawler, & Seddighi, 2000). The lag length selection criterion is based upon model and moment selection criteria (MMSC) for GMM estimation. MMSC depends on the coefficient of determination (CD), Hansen's J statistic, minimisation of modified Bayesian Information Criteria (MBIC), modified Akaike Information Criteria (MAIC), and modified Hannan Quinn Information Criteria (MQIC). Among the lag lengths with valid over-identifying restrictions, the one which minimizes MAIC, MBIC, and MQIC is chosen as the optimal lag length (Tatoğlu, 2020).

Table 4.6 shows the estimated coefficient of determination (CD), Hansen’s J statistics, p-values for Hansen’s J statistics, MBIC, MAIC and MQIC for the patent application and patent granted models.

Table 4. 6 PVAR Model Selection Results

Patent Applications						
Lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	.1916093	15.69238	.4746288	-88.20768	-16.30762	-44.17452
2	.2179401	8.50237	.7447432	-69.42267	-15.49762	-36.3978
3	-2.148634	2.303033	.9702841	-49.647	-13.69697	-27.63042
4	-5.890038	1.901615	.7538482	-24.0734	-6.098385	-13.06511
Patent Granted						
Lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	.9918522	21.84854	.1481498	-82.38687	-10.15146	-38.12148
2	.9920591	6.024482	.9148429	-72.15207	-17.97552	-38.95303
3	.981648	2.250731	.972344	-49.86697	-13.74927	-27.73428
4	.981761	2.280327	.6843531	-23.77852	-5.719673	-12.71218

The lag length that minimizes MBIC, MAIC and MQIC is lag 1 for both patent applications and patent granted models. Thus, the optimal lag length is selected as 1 lag for both models.

The values of dlGDP, dlPA and lPG variables used in the study both in current years and in previous years are important in terms of analysis. At the same time, it is aimed to examine the interaction of dlGDP – dlPA and dlGDP – lPG. For these reasons, the panel VAR method was preferred in the analysis.

This heading examines the PVAR (1) model estimation, which was determined to be the appropriate model, by considering $MSC_{BIC,}$ one of the PVAR model selection criteria for 38 OECD countries. Table 4.7 presents the values of the estimation results of the PVAR (1) model.

Table 4. 7 Findings from GMM PVAR Analysis

Patent Applications		Patent Granted	
	Coefficient [Std.Error]		Coefficient [Std.Error]
dlPA		lPG	
$dlPA_{t-1}$	0.025* (0.067)	lPG_{t-1}	0.000* (0.022)
$dlGDP_{t-1}$	0.512 (0.426)	$dlGDP_{t-1}$	0.826 (0.889)
dlGDP		dlGDP	
$dlPA_{t-1}$	0.045* (0.004)	lPG_{t-1}	0.009* (0.001)
$dlGDP_{t-1}$	0.000* (0.057)	$dlGDP_{t-1}$	0.000* (0.058)

* donates the significance levels at the 5%. Values in parentheses indicate standard errors. The letter “d” in front variables show that the first difference of the relevant was taken.

Table 4.7 shows that the effect of the lagged value of dlPA on economic growth is statistically significant. The effect of lagged economic growth on dlPA is not significant. dlGDP and dlPA are positively affected by their lagged values.

While the lagged lPG variable significantly affects economic growth, the lagged economic growth variable does not significantly affect the lPG variable. In addition, the lagged variables significantly affect their current values.

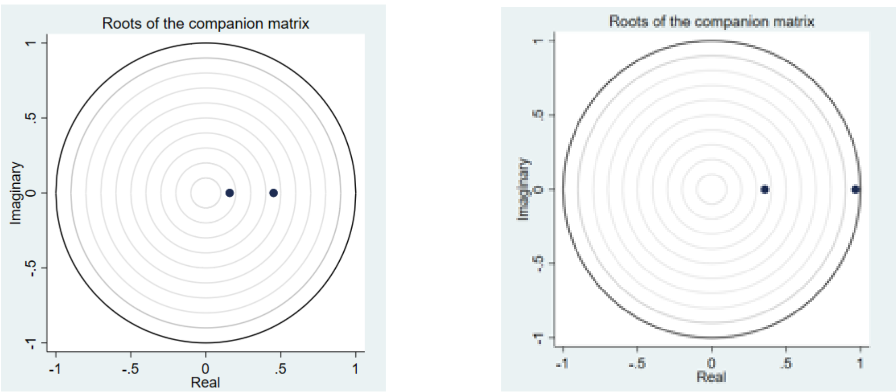
These findings from GMM PVAR (1) analysis indicate that although dlPA and lPG are statistically significant in dlGDP, dlGDP does not significantly affect patents.

4.4.3.1 Stability of the Findings

In order to test the reliability of the results of the PVAR analysis applied in the study, the stability condition must be met. The eigenvalues of the stability condition are presented in Table 4.8 and the eigenvalues graph of the stability condition for countries are presented in Figure 4.1.

Table 4. 8 Eigenvalue Stability Condition

Patent Applications, dlPA			Patent Grants, lPG		
Eigenvalue		Modulus	Eigenvalue		Modulus
Real	Imaginary		Real	Imaginary	
0.4516963	0	0.4516963	0.9662332	0	0.9662332
0.1591063	0	0.1591063	0.3569186	0	0.3569186



Note: Matrix for total patent applications the left and total patent grants on the right.

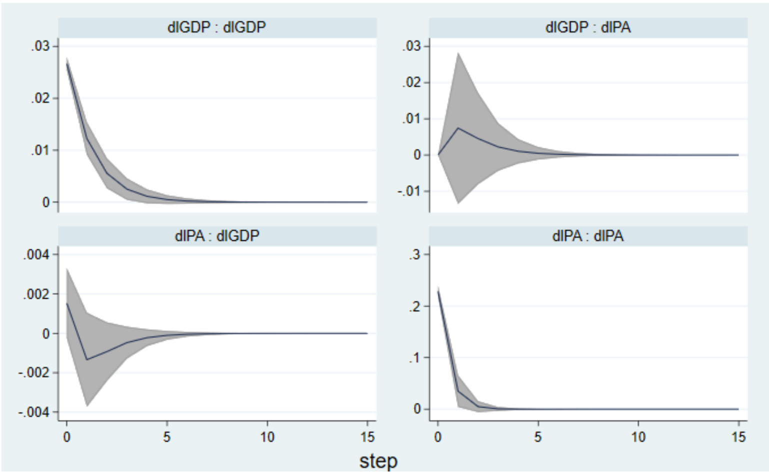
Figure 4. 1 Graph of Characteristic Polynomial Roots

Table 4.8 shows that the eigenvalues are less than 1, the PVAR model created has a stable structure and the stability condition is met. Figure 4.1 shows that all the roots are inside the unit circle and smaller than 1. In line with this information, it can be concluded that the results of the PVAR analysis are reliable. Thus, the relevant panel VAR models are stable.

4.4.3.2 Impulse Response Funtions (IRFs)

After VAR analysis, impulse-response functions are used to determine the dynamic interactions between variables. Impulse-response analyzes were conducted to reveal how and how much the one standard deviation shock in the variables used in the model had an effect on other variables. Generally, the most effective variable on a macroeconomic scale is determined by the variance decomposition, and whether this variable can be used as a policy tool is determined by the impulse-response functions (Luetkepohl, 2005).

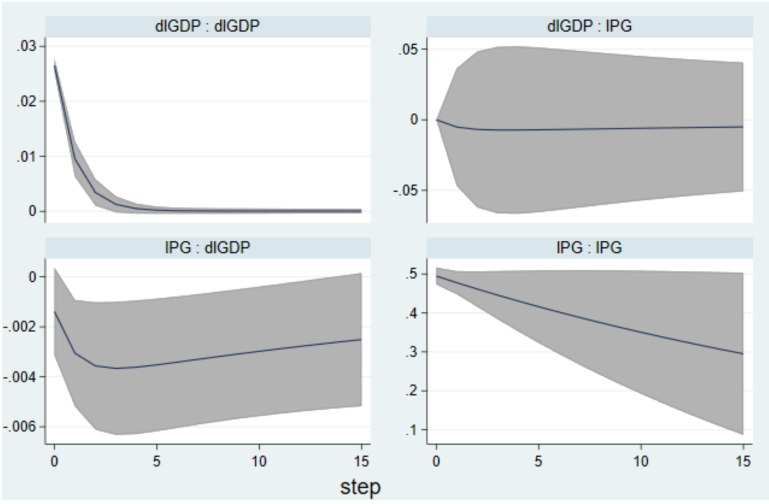
Figures 4.2 and 4.3 indicate the IRFs calculated using 200 Monte Carlo simulations for dlGDP and total patent applications, and dlGDP and total patent grants models, respectively.



Note: Impulse : Response

Figure 4. 2 Impulse Response Functions (IRFs) for dlGDP and dlPA

Figure 4.2 demonstrates that the response of dlGDP to a standard deviation shock applied to dlGDP is statistically significant and positive in the first four periods. However this response decreases and loses its significance in the fifth period. The impact of dlPA on dlGDP is not significant in the first four periods, as presented in the upper-right panel in Figure 4.2. The response of dlGDP to a standard deviation shock applied to dlPA is positive first, then turns negative and the effect dissappears after five periods. Finally, the response of dlPA to a standard deviation shock to the dlPA is statistically significant, it decreases and disappears after the first two periods.



Note: Impulse : Response

Figure 4. 3 Impulse Response Functions (IRFs) for dlGDP and lPG

Figure 4.3 shows that lagged GDP (dlGDP) did not significantly affect lPG because the confidence intervals contain all parts of the zero line, as seen in the upper-right diagram. The response of dlGDP to a standard deviation shock applied to lPG is negative and significant. The impulse of dlGDP on itself can be tracked in the upper-left panel in Figure 4.3, and it presented a positive impact that disappeared in five years. Finally, the one standard deviation shock applied to the lPG gives itself negative and significant.

4.4.3.3 Forecast-Error Variance Decomposition (FEVD)

Another technique used to determine the reasons for the variation in the series is variance decomposition. The variance decomposition analysis, which shows how many percent of a change in the variables is caused by itself and how many percent is caused by other variables, also gives information about the degree of causality relationship between the variables (Enders, 1995). Variance decomposition estimates of the PVAR model are provided in Table 4.9.

Table 4. 9 PVAR Model FEVD Estimates

PA			PG		
Response variable and Forecast horizon	Impulse Variable		Response variable	Impulse Variable	
	dlPA	dlGDP		lPG	dlGDP
dlPA			lPG		
0	0	0	0	0	0
1	1	0	1	1	0
2	0.9989657	0.0010343	2	0.9999433	0.0000567
3	0.998581	0.001419	3	0.9998924	0.0001076
4	0.9984874	0.0015126	4	0.9998566	0.0001434
5	0.9984671	0.0015328	5	0.999832	0.000168
6	0.9984629	0.001537	6	0.9998147	0.0001853
7	0.9984621	0.0015379	7	0.9998022	0.0001979
8	0.9984619	0.0015381	8	0.9997926	0.0002073
9	0.9984619	0.0015381	9	0.9997853	0.0002147
10	0.9984619	0.0015381	10	0.9997795	0.0002206
dlGDP			dlGDP		
0	0	0	0	0	0
1	0.0032797	0.9967203	1	0.0027205	0.9972795
2	0.004774	0.995226	2	0.0139613	0.9860387
3	0.0055631	0.9944369	3	0.0288428	0.9711572
4	0.0057673	0.9942327	4	0.0441917	0.9558082
5	0.0058125	0.9941875	5	0.0587347	0.9412652
6	0.0058219	0.994178	6	0.0721337	0.9278663
7	0.0058239	0.9941761	7	0.0843751	0.9156249
8	0.0058243	0.9941757	8	0.0955398	0.9044603
9	0.0058244	0.9941756	9	0.1057282	0.8942718
10	0.0058244	0.9941756	10	0.1150379	0.8849621

Variance decomposition estimates for both models up to 10-period lag are presented in Table 4.9. The FEVD in Table 4.9 shows how much of the forecast-error variance (FEV) in variables is determined by themselves and how much by the other relevant variable. When the left column of the table is examined, 5 per thousand of the FEV regarding the dlGDP variable at the last delay is determined by the shocks that occurred in dlPA and 99% in itself. 1 per thousand of the FEV of the dlPA variable is determined by the shocks occurring in the dlGDP variable and 99% by itself. When the right column of the table is examined, 11% of the FEV regarding the dlGDP variable at the last delay is determined by the shocks that occurred in lPG and 88% in itself. 99% of the FEV for the dlPG variable is determined by the shocks that occur in it. The forecast-error variance of the dlPG variable is not affected by the dlGDP variable.

In summary, it is observed that the shock experienced in the dlPA variable has no effect on the dlGDP variable and the shock experienced in the dlGDP variable has no effect on the dlPA variable. Also, the shock experienced in the dlGDP variable has no effect on the dlPG variable. Over the period examined, the FEV of total patent grants on dlGDP results in more significant shocks than total patent applications.

4.4.3.4 PVAR Granger Causality Test

After examining the dynamic relationship between variables through the GMM panel VAR approach, the study applies the panel-VAR Granger causality test to determine whether related variables Granger cause each other.

The causality effect of patents on economic growth was tested in the light of the following hypotheses and the panel-VAR Granger Causality Wald Test results are given in Table 4.10.

H_0: There is no causality relationship between patents and economic growth.

H_1: There is causality relationship between patents and economic growth.

Table 4. 10 Findings from Panel VAR-Granger Causality Wald Test

Direction of Causality			chi2	prob>chi2
dlGDP	$\nrightarrow$	dlPA	0.430*	0.512
dlGDP	$\nrightarrow$	lPG	0.048*	0.826
dlPA	$\rightarrow$	dlGDP	4.010	0.045
lPG	$\rightarrow$	dlGDP	6.797	0.009

* denotes rejection of null of the excluded variables does not Granger-cause the equation variable at the 5% level.

From dlGDP to dlPA, the null hypothesis of "H_0: Economic growth is not the reason for patent applications" cannot be rejected at the 5% significance level. From dlPA to dlGDP, the null hypothesis expressed as “H_0: Economic growth is not the reason for patent applications” is rejected at the 5% significance level. As a result, the study finds out a one-way Granger causality from patent applications (dlPA) to economic growth (dlGDP).

From dlGDP to lPG, at the 5% significance level, the null hypothesis of "H_0: Economic growth is not the reason for patent grants" cannot be rejected. The null hypothesis expressed as “H_0: Economic growth is not the reason for patent grants” at the 5% significance level from lPG to dlGDP is rejected. As a result, there is a one-way Granger causality from patents granted (lPG) to economic growth (dlGDP), according to the findings from the panel-VAR Granger causality test.

The empirical research concludes that there is no two-way Granger causality relationship in both models used in the study. The causal relationships obtained from the model show that structural shocks in patents granted (lPG) is subject to a stronger significance compared to the patent application (dlPA).

The findings of the Granger causality analysis can be summarized as follows:

Patent applications → GDP and Patents granted → GDP

4.4 Analysis of Results and Discussions

It is necessary to explain innovation and economic growth as the determinant and output of patents, before discussing patents. Because when analyzing patents, the patent system and its importance, particular concepts and determinants are encountered. At this point, the historical development and basic assumptions of economic growth models and determinants of innovation have been enlightening areas for this study. It is possible to come across many analyzes and studies on the relationship between patent and economic growth using different variables, when the current literature is examined. However, the number of studies on the causal relationship between patents and economic growth in which patent data is used as a variable is limited. In this context, this study uses patent data to answer the questions of whether economic growth affects innovation through patents or whether patents lead economic growth.

Before modern growth theories emerged, technological changes (new machines) had an important place in the ideas of Adam Smith, David Ricardo and Karl Marx (Coombs, Saviotti, & Walsh, 1987). R. Solow is the first economist to include technological development in the modern growth model. The endogenous growth theories examined the nature of the innovation process, evaluated the direction of technological change, and tried to reveal the characteristics that determine the differences of countries in terms of innovative activities. Sustainable economic growth can be achieved through the creation of innovation by industries engaged in R&D and the continuous nurturing of innovation by R&D. R&D-based endogenous growth models have demonstrated their work by advancing with this logic. According to Romer (1986), technological progress is at the center of economic growth and technological innovations emerge as a result of R&D activities. Therefore, he emphasized that economic growth cannot be sustained only with capital accumulation. Romer states that technological change is the factor that will eliminate the development gap between countries. Countries contribute to sustainable economic growth by reusing their profits in R&D expenditures (Romer, 1990). On the other hand, Lucas (1988) stated that technology will contribute to economic growth through human capital in the process of economic growth. Although there are older studies on the positive effects of human capital on economic growth, the model is referred to by Lucas. According to Lucas, the accumulation of human capital in countries can increase as a result of learning by doing (Lucas, 1988). In Lucas' model, human capital accumulation is realized through the education of individuals. The human capital that increases with education ensures the training of qualified manpower. Qualified manpower with increased marginal productivity raises the welfare level of the country and accelerates economic growth. Lucas supports his theory by noting the role of human capital in the miraculous growth rates of Asian tigers.

Joseph Schumpeter is the first economist to emphasize the importance of innovation as a driver of economic growth. Schumpeter states that there are five types of innovations in his model: Introducing a new good, a new type or quality to the market, applying a new technique to production, discovering and creating new markets, finding a new source of raw materials or semi-finished products, and reorganizing the industry. He argues that because of these innovations, the dynamics of the capitalist system will develop continuously.

Innovation has been one of the most important research topics for economists, as most of the improvements in material living standards since the Industrial Revolution have occured through innovation (OECD, 2006). Most countries' demand for patents has been rapidly expanding since the mid-1990s. Patents are becoming more and more important in innovation and economic performance. University patenting promotes knowledge transfer between universities and businesses while also facilitating information commercialization by providing a market for technologies. In this respect, the strong patent system promotes technology transfer between universities (public) and the private sector. While the extension of patent protection does not always have a strong impact on innovation activities, it does appear to affect the behavior of many types of companies. Because patents play an important role in market-centered innovation systems. In order to evaluate the ability of patent systems economic criteria should be used more systematically to foster innovation and technology diffusion. Increasing the level of knowledge and awareness of companies about the issues and processes related to patents and intellectual property rights can be considered as the first step of the patent system.

The aim of this thesis is to analyze whether there is a causality relationship between patents and economic growth. For this purpose, the relationship between patents as an indicator of innovation and economic growth was analyzed empirically by using the data of 1990-2019 period and panel time series analysis in OECD countries. First of all, the cross-sectional dependence test (Pesaran CD test) was employed. As a result of the analysis, it is concluded that there is a cross-sectional dependency. In the second step, the CADF unit root test was employed to test the stationarity of the variables. As a result of the unit root test, it was decided that the variables lPA and lGDP are not stationary at the level and the analysis was continued by taking the first differences of these variables. In the third step, PVAR analysis and panel Granger causality test were performed, and according to the test results, there was no two-way relationship between patent applications, patents received and GDP. It has been revealed that there is a causality relationship from patent applications (dlPA) and patents granted (lPG) to GDP (dlGDP). According to the findings obtained from the forecast-error variance decomposition, while the significance level of lPG on dlGDP is stronger, its effect in dlPA is lower. The results of the analyzes reveal that there is a causality relationship from patents to economic growth, similar to several studies in the literature. Almost all OECD member countries are advanced and have high-income levels. Already, OECD countries encourage innovation by investing in R&D and provide support for policies that emphasize the importance of market size for effective R&D sectors (Acemoğlu & Linn, 2004). Approximately 62% of the patent applications filed worldwide were filed by OECD countries in the analyzed 30-year period. It is possible to conclude that more patents are granted in developed countries based on this information. On the other hand, if a country's income is not high enough, it is difficult to carry out R&D activities in that country. Since patenting is a direct function of R&D activities, without R&D there is no patenting. For this reason, the income level and economic development of countries also have an impact on patents. Since a third variable (i.e. R&D expenditures) is not used in the panel-VAR Granger causality analysis employed in this study, it is concluded that there is a one-way causality from patents to economic growth. As a result of the analysis, it can be said that this study supports endogenous growth theories, since a significant relationship was found between innovation (patents) and GDP.

Technological progress is accepted as the primary determinant of long-term growth. This technological progress arises from the activities of companies that involve the launch of new products (Romer, 1990; Grossman and Helpman, 1991) or the development of existing products (Grossman and Helpman, 1991; Aghion and Howitt, 1992). The endogenous growth theories are based on three theorems (Snowdon & Vane, 2005). First, the main reason behind economic growth is technological change, which is the progress made in the transformation of inputs into outputs in the production process. Second, technology is an economically endogenous variable. It largely consists of the conscious activities of actors pursuing economic gain. Third, once a new idea is created, it can be used over and over again at no additional cost. In R&D-based growth models, the main output of R&D activities is new products and their patents. New designs created as a result of R&D activities are protected by patents. Therefore, the number of patents is an indicator of how efficient R&D activities are in a country. Using R&D data in the analysis brings with it some problems. Especially in developing countries, R&D data is either not available as a time series or can be found for a short time period. R&D activities may not result in an invention or a patent. Therefore, R&D activities that do not result in any patents, innovations, or products, no matter how large, have no value in terms of economic analysis (EIMS, 1996).

As new technologies are introduced, it becomes difficult to classify these new technologies into new patent classes, and in such cases, patent data for new technologies remain raw data (OECD, 1994). The fact that the patent propensity differs from company to company, sector to sector and country to country makes it difficult to make comparative analysis between companies, sectors and countries. For these reasons, analyzes can also be made by selecting patent data for a product, sector or country.

Changes in economy and technology around the world in recent years have brought the concept of a knowledge economy to the agenda. According to the World Bank Knowledge Economy Index (KEI) and Knowledge Index (KI) for 2012, Sweden, Finland, and Denmark are among the top three OECD countries in terms of knowledge economy indexes. According to the economic incentive system, Finland is the best performing country. Among OECD countries, Germany, Estonia, the Czech Republic and Slovakia have made the greatest progress in the knowledge economy. On the other hand, Mexico, USA, Turkey and Israel are the countries with the highest regression in the ranking. It is important to provide incentives for innovation and protection of IPRs, especially in knowledge-based economies. In addition, it should be aimed to establish strategic goals for the effective management of patents, since patents contribute to a company's balance sheet and have a monetary value that increases the value of the enterprise. Patent protection is important for firms to maintain competitive advantage and to enable patent holders to reap the benefits of their investment in innovation. Moreover, a country's trade policy positively affects the contribution of patents to growth.

CHAPTER 5

5. CONCLUSION AND RECOMMENDATIONS

The objective of this dissertation study was to assess whether there is a significant relationship between patents and economic growth as pointed out by endogenous growth theories that emphasize the positive impact of R&D activities on economic growth. In this regard, this study examines the mutual relationship between patents and economic growth by distinguishing patents into patent applications and patents granted. Thus, two econometric models are used to investigate the relevant nexus in this study. The study covers a panel of 38 OECD economies between 1990 and 2019 and employs panel VAR and Granger causality techniques from panel time series approaches. All the analyses were carried out using the Stata 17 package program. The findings show that there is a one-way relationship from patents (both applications and grants) to GDP, similar to the studies in the literature. The study generally shares common features with R&D-based endogenous growth models and Schumpeter's innovation approach model.

Literature review section of the study shows that the findings of this study is similar to the other research findings in the literature. For example, Schmookler (1966) concluded that patents have a positive effect on economic growth in the long run. Similarly, Bilbao-Osorio (2004) examined the relationship between the number of patents, economic growth and R&D expenditures for the European Union country group in the period of 1990-1998 with panel data analysis and it was concluded that the increase in the number of patents had a positive effect on economic growth. The finding obtained in this thesis study is that there is a one-way causality relationship from patents to economic growth. However, it has been concluded that the structural shocks that occur in patent granted are more significant on gross domestic product than patent applications. The reason for the causality relationship obtained may be that the country group examined in the study consists of the largest economies in the world and that these countries focus on the issues affecting the innovation performance in order to ensure sustainable economic growth. It is also known that in many of the high income countries, incentive mechanisms to increase the number of patents obtained by both the public (especially universities) and the private sector are working well. In addition, it is thought that important contributions to the literature will be provided if studies on the patent-economic growth relationship are conducted with different periods, country groups, variables and analysis methods.

Nowadays, while the economies of many countries are undergoing major transformation and change, the measures we need to take and the policies we need to establish to adapt to the new economic structure in the globalizing world are important. According to the findings obtained from the analyses and theoretical literature, it is important to develop training programs to increase entrepreneurship culture, increase incentive mechanisms, to establish an effective patent management system to support innovation activities, and put into effect incentive policies for the development of high-value added technology products. An R&D culture should be created in companies and necessary resources should be allocated for R&D. Economic and social development policies should focus on innovation. For this purpose, the tax system, incentives, and regional and urban development strategies should be reorganized and successfully implemented. Countries should implement development policies that provide tax reductions and exemptions for the creation of patentable new ideas as a result of R&D activities in the public and private sectors and increase the interaction between universities that produce theoretical knowledge and industry that transforms theoretical knowledge into economic value.

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