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THE EFFECTS OF TECHNOLOGY AND INSTITUTIONS ON PRODUCTIVITY GROWTH, A SECTORAL APPROACH IN THE CASE OF SOME OF THE OECD COUNTRIES

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This dissertation aims to obtain a doctoral (Ph.D.) degree in the scientific field of "Management and Business"

Written by: Vahid Zeynvand Lorestani, certified ……………………………

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DECLARATION

I undersigned (name: VAHID ZEYNVAND LORESTANI, date of birth: 1981.09.21), declare under penalty of perjury and certify with my signature that the dissertation I submitted to obtain a doctoral (Ph.D.) degree is entirely my work.

Furthermore, I declare the following:

- I examined the Code of the Károly Ihrig Doctoral School of Management and Business Administration, and I acknowledge the points laid down in the code as mandatory;
- I handled the technical literature sources used in my dissertation fairly, and I conformed to the provisions and stipulations related to the dissertation;
- I indicated the source of other authors' unpublished thoughts and data in the references section completely and correctly in consideration of the prevailing copyright protection rules;
- No dissertation that is fully or partly identical to the present dissertation was submitted to any other university or doctoral school to obtain a Ph.D. degree.

Debrecen,
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VAHID
ZEYNVAND LORESTANI

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INTRODUCTION

Today, "Economic Growth" is considered the most essential aim, and every nation is working toward that end. The answer to the issue of why the expansion of an economy is of the biggest significance to a country is, ultimately, connected to the standard of living of its population. Improved quality of life for the general population is one of the goals of economic development. If economic growth does not increase the general living standard, then the concept of "development" cannot be said to have occurred. According to sociologists, economists, and politicians, the improvement of everyone's quality of life should be the overarching goal of economic policy (Firebaugh & Beck, 1994).

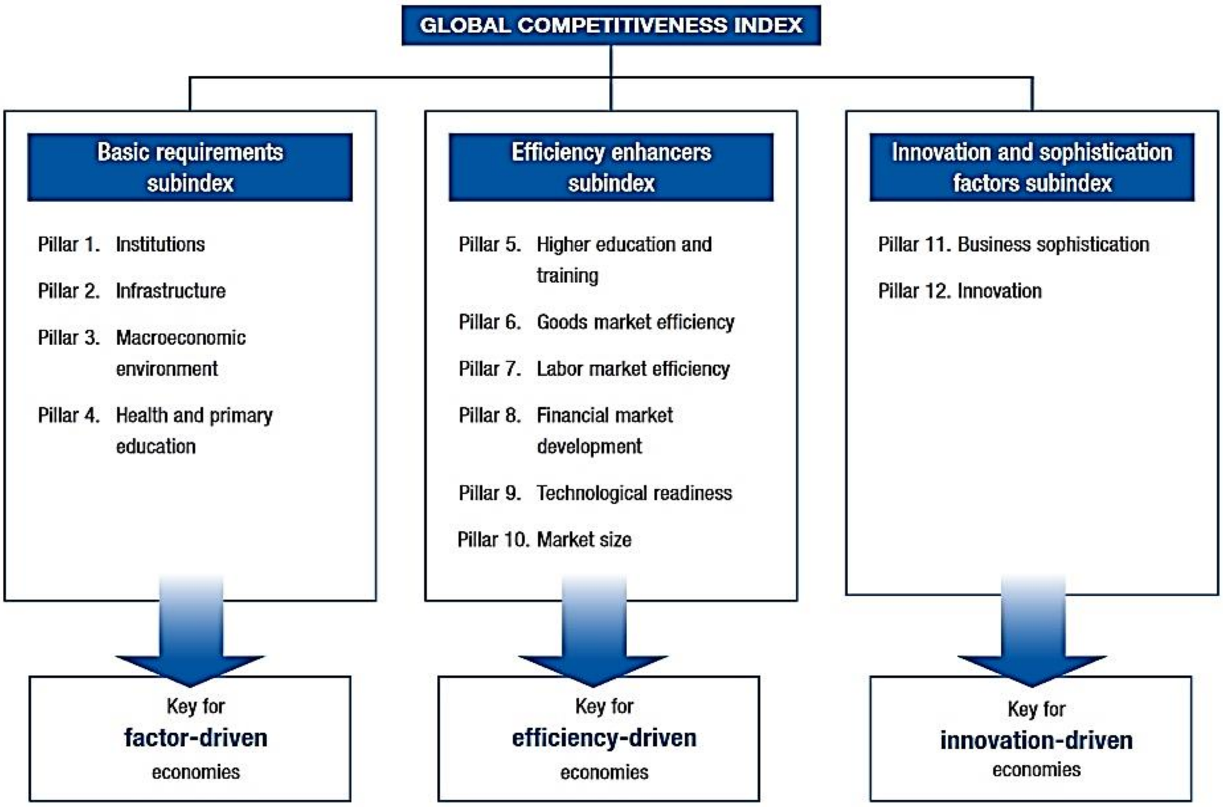
A nation's economy grows as a result of the interaction of several basic elements. Many scholars believe that human capital is the most important component in determining overall productivity. According to HARBISON & MYERS (1964), "The formation of modern countries rests upon the growth of people and the organization of human activity." Although some other factors, such as capital, natural resources, and international cooperation, contribute significantly to economic expansion, the single most essential factor is "labor force" participation.

The World Economic Forum, well-known for being one of the sources that collect data on the global economy and analyze the performance of all economies, displayed a structure that included components of competition between countries, ultimately resulting in economic growth.

Lall (2001) expressed that “Many policymakers express serious concerns about national competitiveness”. Kordalska and Olczyk (2016) found that the Global Competitiveness Index is accurate in projecting economic growth for the vast majority of countries with low incomes as well as OECD high-income countries. It was done to show how competition among countries finally results in economic.

Figure 1 demonstrates that there are twelve pillars and three sub-indexes of the Global Competitiveness Index (basic requirements, efficiency enhancers, and innovation & and sophistication factors). Among the mentioned pillars, "Institutions" and "Technology" play important roles in achieving global competitiveness, which in turn leads to economic development in a country.

Figure 1

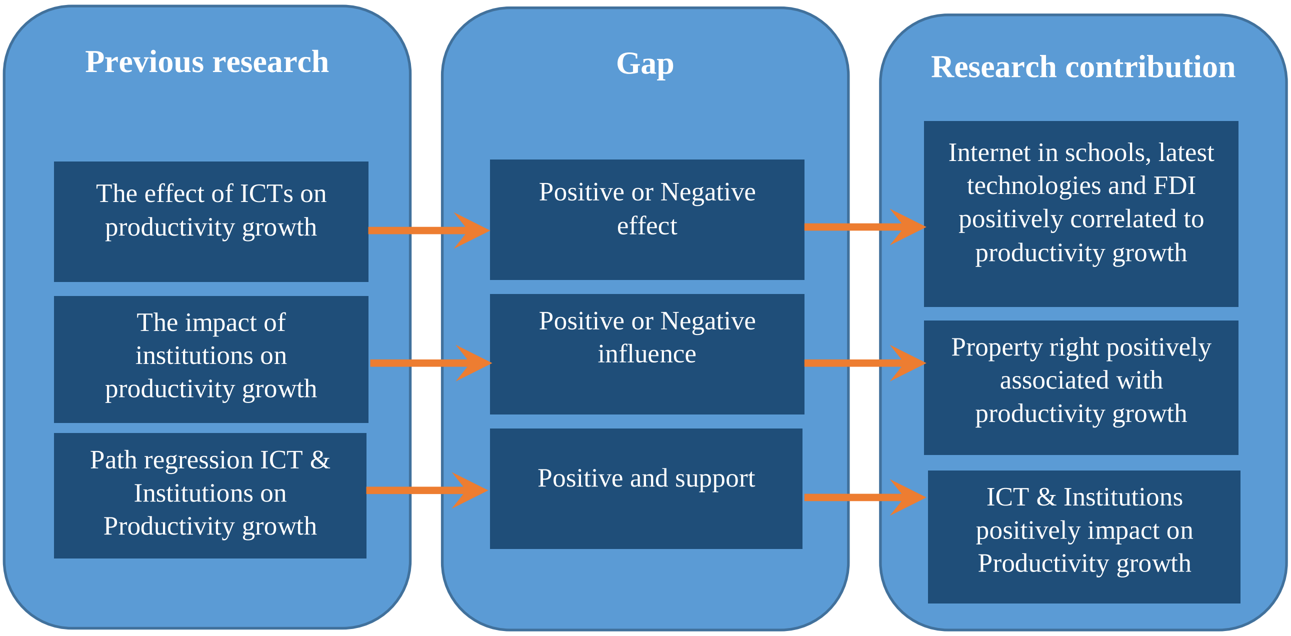


Source: World Economic Forum, 2018

This study aims to contribute to the empirical research by evaluating the influence of technology (ICT) and institutions on the increase of productivity in a sectoral approach in some of the OECD countries from 2008 to 2018. This study concentrates on the direct question of how the availability of information and communications technology (ICT), such as internet access in schools, availability of the latest technology, and foreign direct investment, as well as institutional concerns such as property rights, are connected to the rate of enhance in productivity. The data sets compiled by the World Economic Forum (GCI dataset), OECD STAN database, EU KLEMS, and Penn World Table, were used as the basis for the study, and specific variables were taken from those sets. The empirical data from the dynamic GMM (Generalized Method of Moments) regressions support that there is a positve relationship between access to the internet in schools and productivity growth. The availability of the latest technologies affects economic development. Furthermore, there is a direct relationship between productivity growth, foreign direct investment, the transfer of technology, and property rights. Therefore, the support of competitiveness objectives by increasing the mentioned variables may make some of the OECD countries more competitive and maintain economic development.

Figure 2

Research Gap and Study Contribution



Source: Author's compilation (2022)

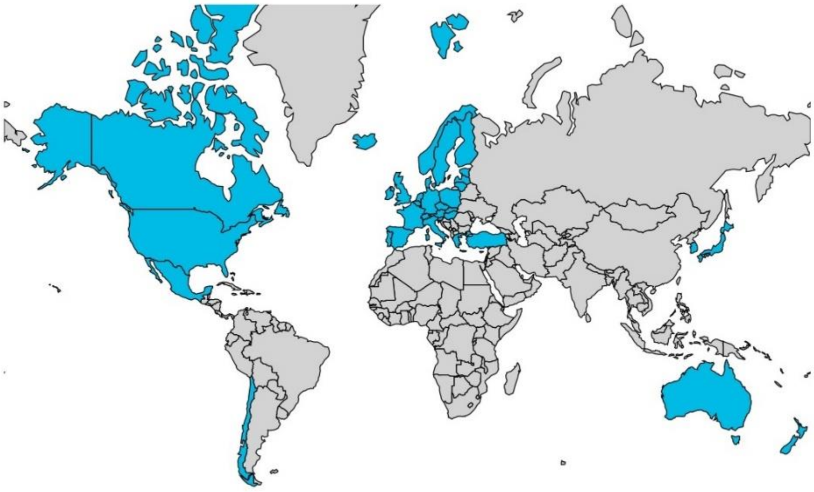
In this research, the first chapter provides a concise description of the issues and aims of the study, and the second section illustrates the conceptual literature framework and background of this research topic. The industry classification described in Chapter 3, data collection and methodology are both described in Section 4 as well. The findings, analysis, and debate were covered in Section 5, which the reader may see below. The rest of the research will consist of a conclusion, followed by the ramifications of the study and the novel findings discovered during the research.

- **OECD Countries**

The Organization for Economic Cooperation and Development (OECD) is a global organization whose mission is to work toward the development of better policies to improve people's living conditions. It seeks to construct policies in such a way that they promote prosperity, equality, opportunities, and well-being for all people. The OECD relies on its sixty years of experience and ideas to better prepare the world for the future. The OECD works with governments, policymakers, and people to set worldwide standards that are evidence-based and to provide solutions to a variety of social, economic, and environmental concerns. The Organization for Economic Cooperation and Development (OECD) provides a unique forum and knowledge hub for data and analysis, the exchange of experiences, the sharing of best practices, as well as advice on public policies, and the setting of international standards.

Figure 3

OECD Countries Map 2022



Source: www.worldpopulationreview.com

On the 14th of December in 1960, the Convention on the Organization for Economic Cooperation and Development was first signed by a total of twenty nations. Since then, eighteen countries have joined this organization.

Table 1
OECD Countries List, 2022

No.	Country	No.	Country	No.	Country
1	AUSTRALIA	14	GREECE	27	NEW ZEALAND
2	AUSTRIA	15	HUNGARY	28	NORWAY
3	BELGIUM	16	ICELAND	29	POLAND
4	CANADA	17	IRELAND	30	PORTUGAL
5	CHILE	18	ISRAEL	31	SLOVAK REPUBLIC
6	COLOMBIA	19	ITALY	32	SLOVENIA
7	COSTA RICA	20	JAPAN	33	SPAIN
8	CZECH REPUBLIC	21	KOREA	34	SWEDEN
9	DENMARK	22	LATVIA	35	SWITZERLAND
10	ESTONIA	23	LITHUANIA	36	TURKEY
11	FINLAND	24	LUXEMBOURG	37	UNITED KINGDOM
12	FRANCE	25	MEXICO	38	UNITED STATES
13	GERMANY	26	NETHERLANDS		

Source: www.oecd.org

In this study, I investigate the impact of information and communications technology (ICT) and institutions on economic development in some of the OECD countries.

Furthermore, in the sectoral approach, I applied skill taxonomy, innovation taxonomy, and R&D intensities taxonomy to classify the mentioned variables.

1. TOPICS AND OBJECTIVES

1.1 Aim of the research

The thesis aims to highlight the interactions between GDP per capita (productivity), Information Communication Technology (ICT), and Institutions.

1.2 Objectives of the research

1. The first objective of this research is to investigate the influence of technology on productivity in some of the OECD countries' sectors in a sectoral approach.

2. The second objective is to identify the influence of institutions on productivity in different sectors in some of the OECD countries in a sectoral approach.

3. Also, to find the proper methodologies and adapt models suitable for analyzing longitudinal and cross-country differences in this research.

1.3 Research questions

Based on the research objectives, the below research questions have been made:

1. How can technology (ICT) influence productivity in different branches?

2. How do institutions affect productivity in different country groups and sectors?

1.4 Structure of the thesis

This section is an overview of the path that will be followed to attain the research objectives and the research structure, literature review, data and methodology, analyses, results, and lastly, the main conclusion and novel findings (Figure 4).

Chapter 1 clarifies the topics and objectives of the dissertation. The main objectives of the study are the effect of technology and institutions on productivity and economic growth. Furthermore, descriptive methods are proposed and empirically tested to determine how these interact with each other.

Chapter 2 is a literature review. It shows how the scholars studied the effect of technology and institutions on economic growth. This chapter also forms the theoretical basis used to hypothesize and analyze this dissertation.

Chapter 3 In this chapter, the sectoral approach of the research is mentioned. Hence, Industry classification such as skill taxonomy, innovation taxonomy, and R&D intensities taxonomy describe the findings shown in this part.

Chapter 4 explains the databases and methods applied to attain the research objectives and answers the research questions.

STATA software (version 15.0x64) was used to analyze and explore the dynamic regression by the two-step GMM method.

Chapter 5 shows the research findings and discussion. The variables are compared at the beginning of the chapter. Dynamic panel regression was used to test the hypotheses of the study.

Chapter 6 Describes the concluding remarks of the study and specifies the limitations based on the implications, which also include future directions and recommendations for policymakers and the novel findings of the dissertation.

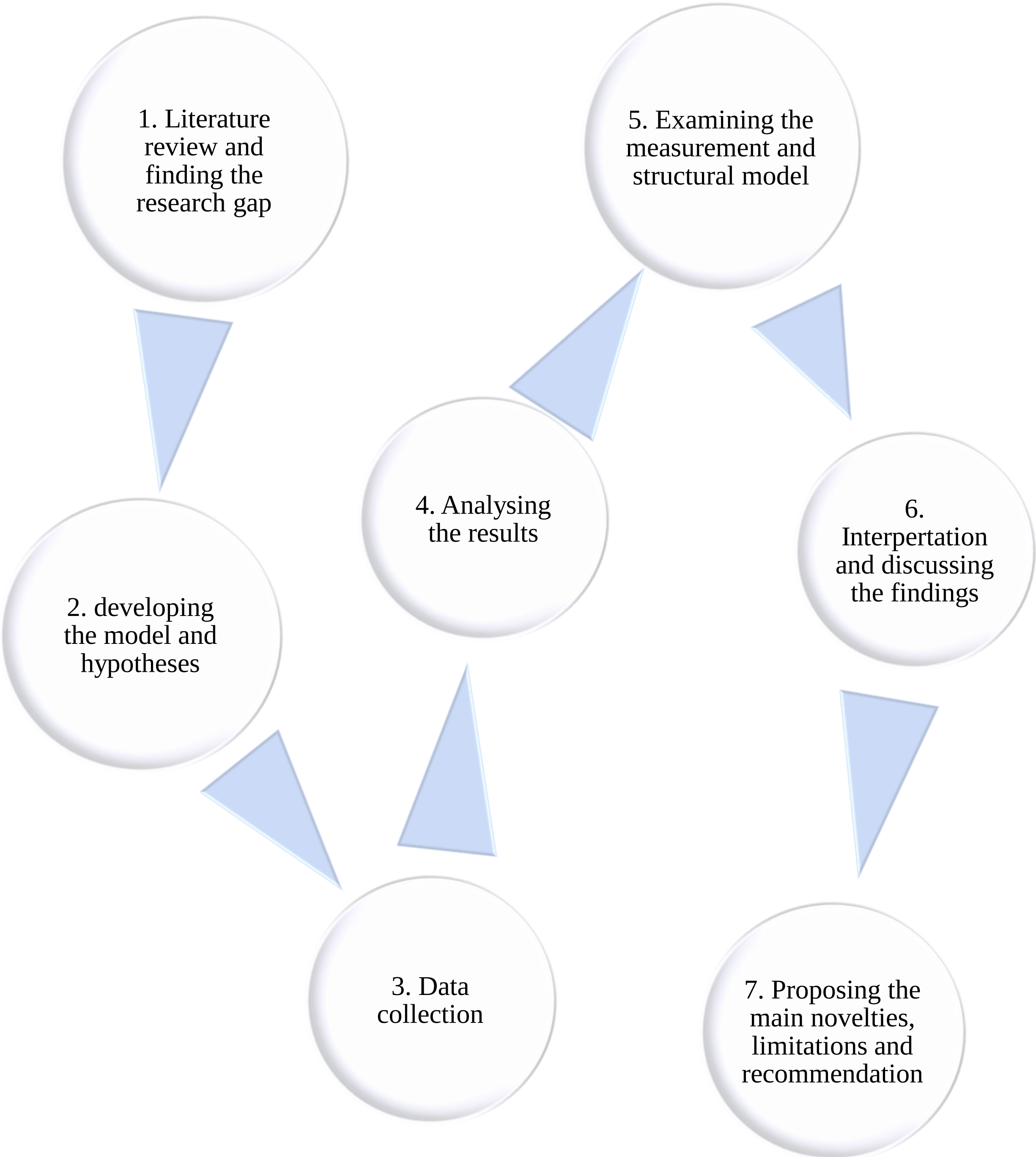
The dissertation ends with a list of tables, figures, publications, and references.

1.5 Research approach

This research started by reviewing the previous studies that examine the direction of the internet in schools, the latest technology adoption, FDI and technology transfer, as well as property rights.

Figure 4

Research approach



Source: Author's compilation (2022)

1.6 Hypotheses development

After summarizing the previous research, this study proposed to develop the six hypotheses as follows.

The hypotheses suggested studying the influence of ICT and institutions on productivity growth.

In proposing a novelty as the theoretical framework of this research, this study argued that Internet access in schools would affect productivity growth. Then, the availability of the latest technology would increase productivity growth, and FDI and technology transfer have the same effect on productivity growth. This research proposed the effect of ICT on productivity growth in the three hypotheses below.

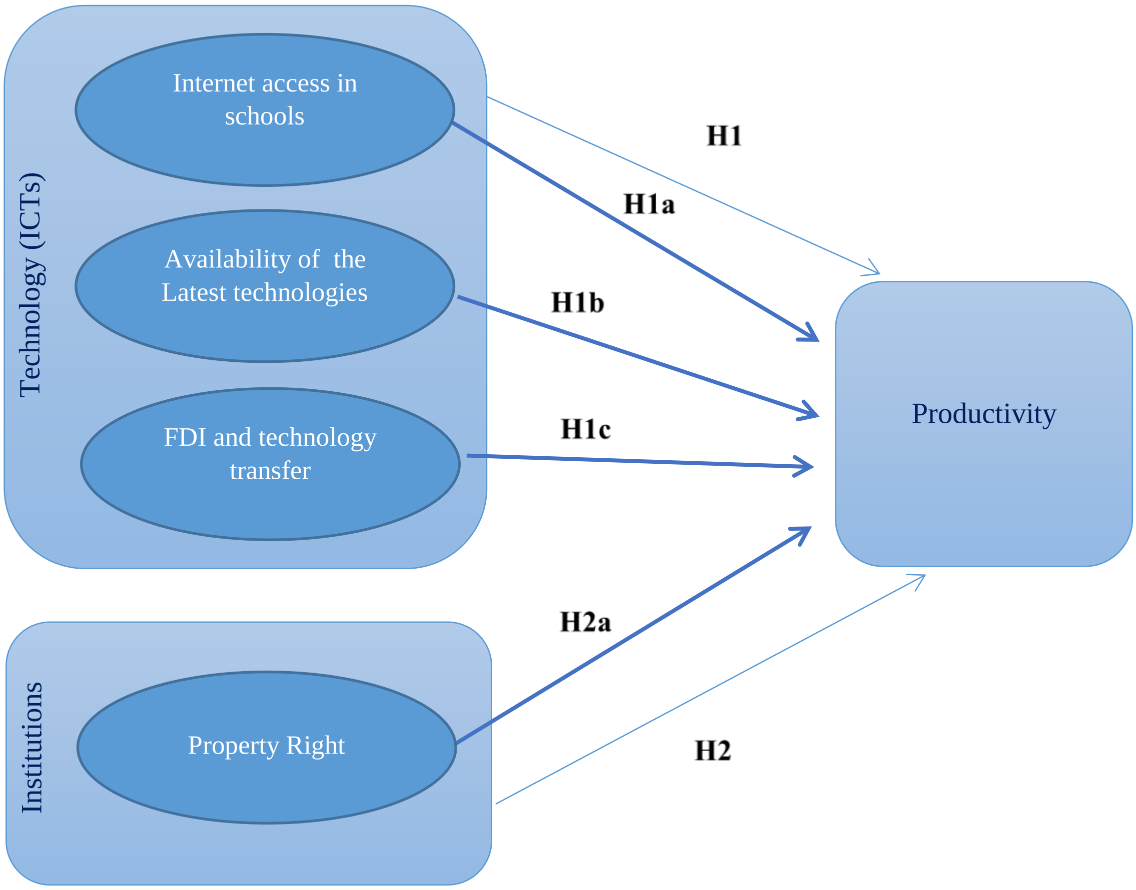
> **Hypothesis 1:** ICT is positively associated with productivity growth in some of the OECD countries and sectors.
>
> **Hypothesis 1a.:** Internet access in schools positively affects productivity growth in some of the OECD countries and sectors.
>
> **Hypothesis 1b:** Availability of the latest technologies positively correlated with productivity growth in some of the OECD countries and sectors.
>
> **Hypothesis 1c:** FDI and technology transfer positively influence productivity growth in some of the OECD countries and sectors.

This research proposed that property rights as an institutional indicator might affect the level of productivity growth.

> **Hypothesis 2:** Institutions are positively associated with productivity growth in some of the OECD countries and different sectors.
>
> **Hypothesis 2a:** Property rights positively influence productivity growth in some of the OECD countries and different sectors.

Figure 5

Summary of the hypothesis



Source: Author's compilation (2022)

2. LITERATURE REVIEW

This research briefly reviewed the previous studies about internet access in schools, availability of the latest technologies, FDI and technology transfer, and property rights as indicators of ICT and institutions, respectively.

All articles presented and cited in this literature review have been published in the scientific journals.

The literature focuses directly on the important role of the mentioned independent variables and their function in today's world.

The data relating to each variable was collected from reputable databases.

At the end of each section, I tried to review the scholar's claims about these questions: "How does the access to and usage of ICT as internet access in schools, latest technology, and foreign direct investment as well as an institution matter as property rights, are related to the pace of productivity change?"

The related information, tables, and figures are also presented in this chapter.

This chapter aims to describe the above subjects in some of the OECD countries and compare the situation between the countries located in these regions in the case of ICT and institutions matters.

The data presented in the tables and figures in this chapter were collected from well-known international databases such as EU KLEMS, World Economic Forum, OECD STAN database, Penn World Table, and World Bank.

2.1 Productivity

Productivity is not the be-all and end-all. But in the grand scheme of things, it amounts to virtually everything (Paul Krugman, 1994). Based on the description provided by the European Productivity Agency, with some adjustments provided by the Japan Productivity Centre, productivity may be seen as a social notion and is presented as an "attitude of mind."

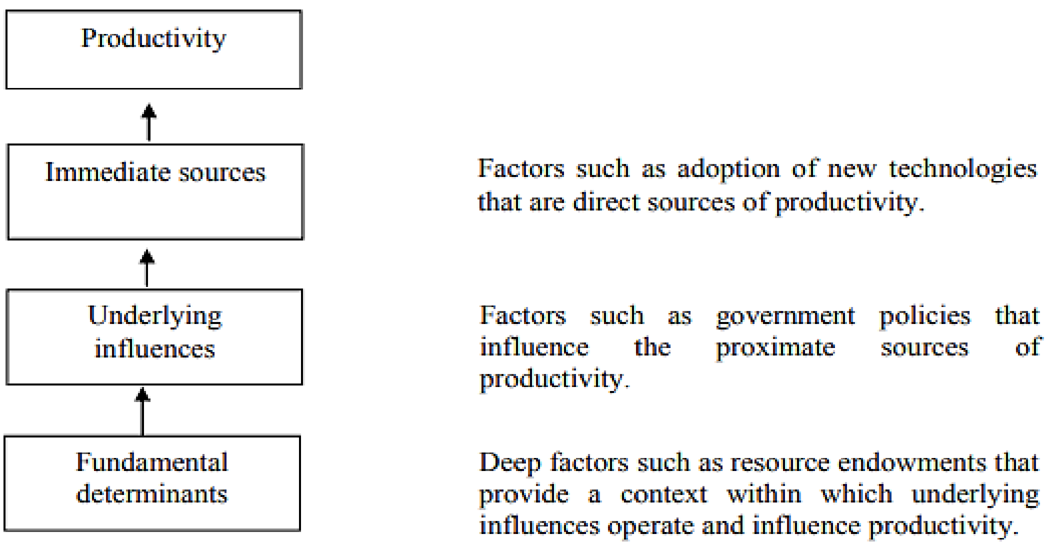
Productivity may be understood primarily in three different ways:

1. Since efficiency and productivity are synonymous, "output divided by input" is the formula for calculating productivity.
2. Productivity may be calculated by taking the ratio of output to input plus one (output divided by objective as productivity). According to this interpretation, productivity may be seen as the combination of two other concepts: effectiveness and efficiency.
3. When productivity is discussed, it is often in the context of the all-encompassing belief that everything that makes up a company has better performance.

Growing one's productivity is the only way to ensure long-term profitability, efficiency, and expansion of one's business. Productivity is a crucial aspect that must be taken into consideration for both operational and process management. The constraints that are placed on organizational resources, such as financial and human resources, may be better managed and alleviated via the improvement of productivity.

Figure 6

Productivity Influencers Hierarchy



Source: (Parham & Economics, n.d.)

2.1.1 Types of Productivity

Productivity may be broken down into two main categories:

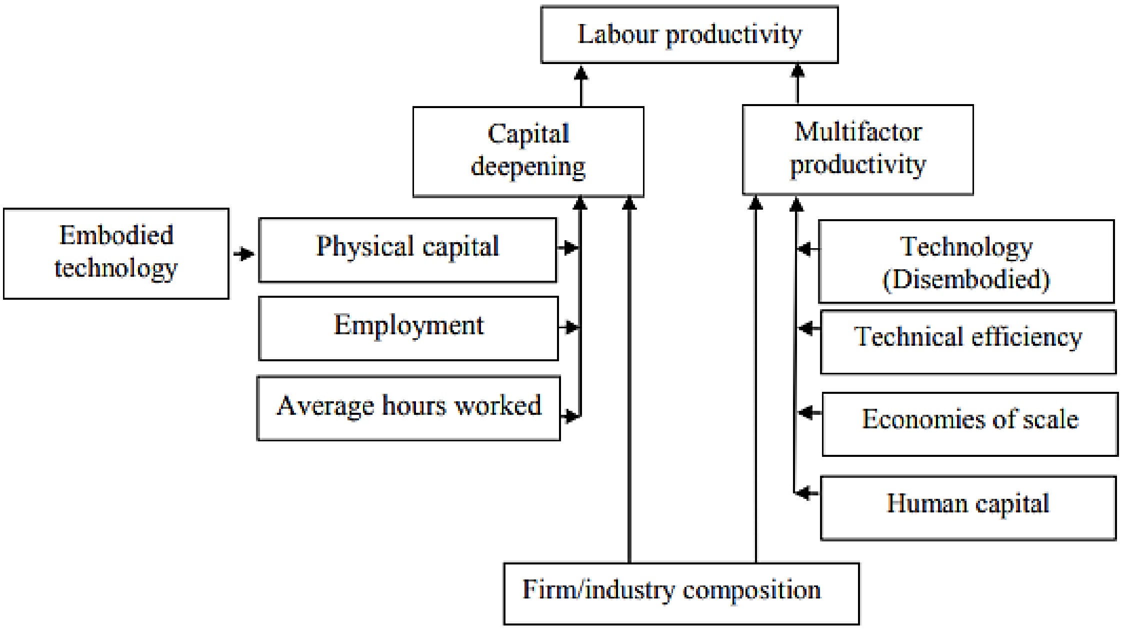
- The ratio of output to the amount of work that was put in may be thought of as labor productivity. In most cases, the quantity of product generated is measured in terms of the number of hours worked.
- The ratio of output to the sum of labor and capital as inputs when we talk about multifactor productivity. This particular metric is also referred to as total factor productivity on occasion.

2.1.1.1 Labour Productivity

Labor productivity may be defined as the ratio of production to labor input. Output can be influenced by several elements, including the kind and total amount of available capital equipment, management performance, know-how technologies.

Figure 7

Labor Productivity Sources



Source: (Parham & Economics, n.d.)

On a national scale and when seen from the viewpoint of the economy as a whole, labor productivity may be understood as a measure of richness. Labour, multifactor, and total factor productivity measures are related to each other and gross domestic product (GDP) per capita (Diewert & Nakamura, 2007)

2.1.1.2 Multifactor (Total factor) Productivity

The term "efficiency" may be interchanged with this kind of productivity. The concept of multifactor productivity refers to the combination of labor and capital, both of which are indicators of production, to create output efficiently and effectively. Investment in healthcare and research and development, which will improve the climate for innovation, is connected to increases in worker productivity. To achieve this goal, the role that governments play in offering incentives to private citizens as a means of fostering innovation and increasing total factor productivity is particularly crucial. In the study of economics, total factor productivity (TFP) is referred to as multi-factor productivity. It takes into consideration the impacts of cumulative output developments relative to the growth of conventionally measured inputs like capital and labor. When all of the inputs are taken into account, it is also regarded as an essential measure of a company's competitiveness.

Hall & Jones (1999) have proven that the majority of the gaps in per capita income between developed and developing countries are linked to some cross-country differences in TFP levels due to variations in technology levels. They attributed these differences to the fact that developed countries have access to higher levels of technology. According to research by Thompson & Rushing (1996), an increase in TFP has a statistically significant and beneficial impact on economic development. Furthermore, this study was shown to be valid for a comprehensive sample that included countries with both high and low incomes.

2.1.2 The importance of productivity

Productivity is vital to businesses from a microeconomic point of view since it creates (and maybe increases) the duties of workers, investors, and governments while at the same time allowing them to remain continuously competitive in the markets. It is well acknowledged that productivity is one of the most important factors in determining an organization's level of success in the current global and competitive environment (Nachum, 1999).

When viewed from the perspective of macroeconomics as a whole, an increase in productivity leads to an improvement in living standards. This is because an increase in people's income improves their ability to purchase goods, which in turn leads to an improvement in the educational system and contributes to social and environmental planning. When viewed over extended periods, seemingly little shifts in rates of productivity growth may, similar to the accumulation of interest in an account, snowball into substantial disparities in the level of wealth enjoyed by a community. Nothing else is more important to alleviating poverty, expanding opportunities for leisure, and the capacity of a nation to fund such things as education, public health, the environment, and the arts, among other things (Baumol & Blinder, 2019). The 1990s saw the beginning of a new approach to understanding the increase in productivity.

According to the evidence, the following three elements seem to be the most important contributors to increased productivity in some nations:

• Increased competition is necessary to expand productivity; hence, businesses should strive to do so. Businesses get the incentive they need to improve their actions to remain in the market and expand as a result of competition.

• Outsourcing production on an international scale became possible due to globalization and the role that institutions played in its development. The development of "Institution Matters" and the combination of economies based on institutions, business, and investment brought about this opportunity. All in all, according to Acemoglu & Johnson (2003), there is strong support for the importance of institutions on economic outcomes.

Globalization helped boost productivity by increasing the level of rivalry between institutions. This led to the reorganization of production in an international setting, which ultimately resulted in the highest level of efficiency.

• The expansion of "Information Communications Technology" (ICT), on the one hand, created opportunities for productivity growth directly, and on the other hand, supported globalization by providing suitable information transfer and global cooperation of economic activities.

2.1.3 Productivity measurement

According to the findings of scholars, production may be measured in terms of both effectiveness and efficiency simultaneously (Kumar & Gulati, 2010). Cervantes-Godoy & Dewbre (2010) have compiled a list of the essential elements that have a significant impact on economic development and productivity. These factors include access to raw materials and inputs; access to markets that are supported by adequate transportation, marketing, processing, and infrastructure; a tax and trade policy that does not discriminate; high rates of investment in agricultural research and extension; a system of ownership rights that encourages initiative; technological facilities; employment-creating small and medium-sized enterprises; well-functioning institutions; and good governance, so on.

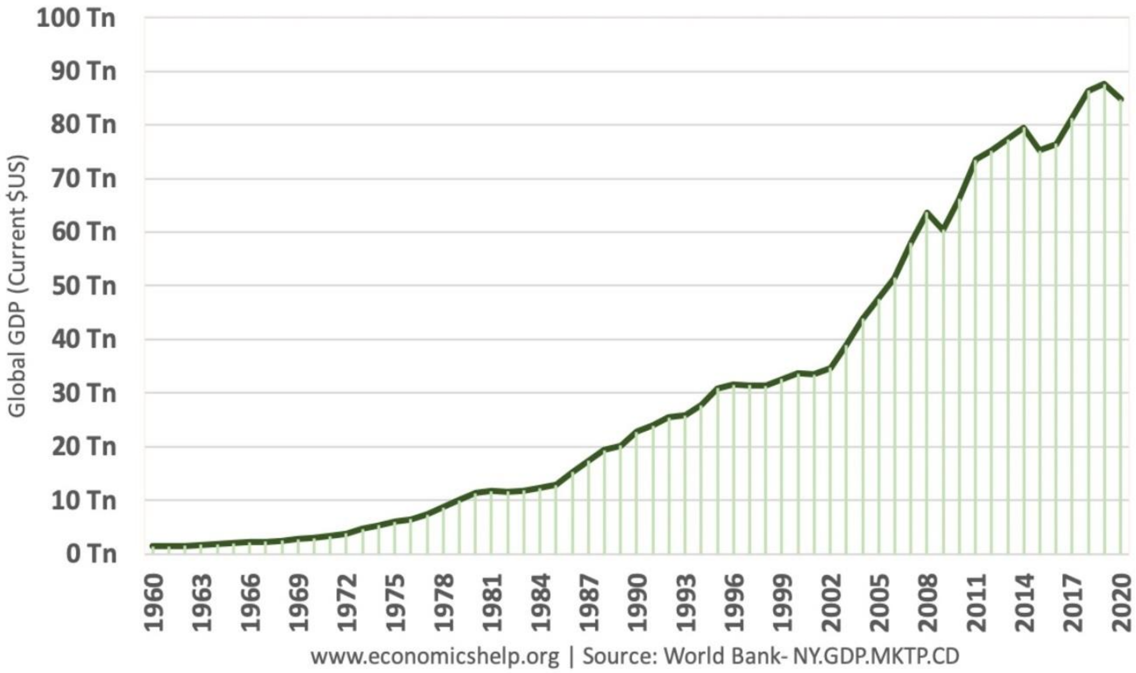
2.1.4 Productivity and GDP per capita

The gross domestic product (GDP) per capita is a metric that is used to rank countries according to their levels of productivity, which are determined by taking into consideration the following three factors: output per worker, average hours worked in each year of work, and output relative to the total population. If one nation's gross domestic product (GDP) per person is more than that of another, then the first nation is the more productive nation overall. That indicates that, in comparison to other nations, it takes less time to manufacture products and provide services in that particular nation. Productivity and gross domestic product (GDP) per capita have a strong and robust connection. Even though there is a wide range in productivity from country to country, many nations have a GDP per capita of about thirty thousand dollars. The reason for this is that the GDP per capita represents a country's productivity over a lengthy time, but productivity, in general, decides whether or not a country's economy will increase in the future.

Figure 8

Global GDP

2021



2.1.5 GDP growth by country in 2021

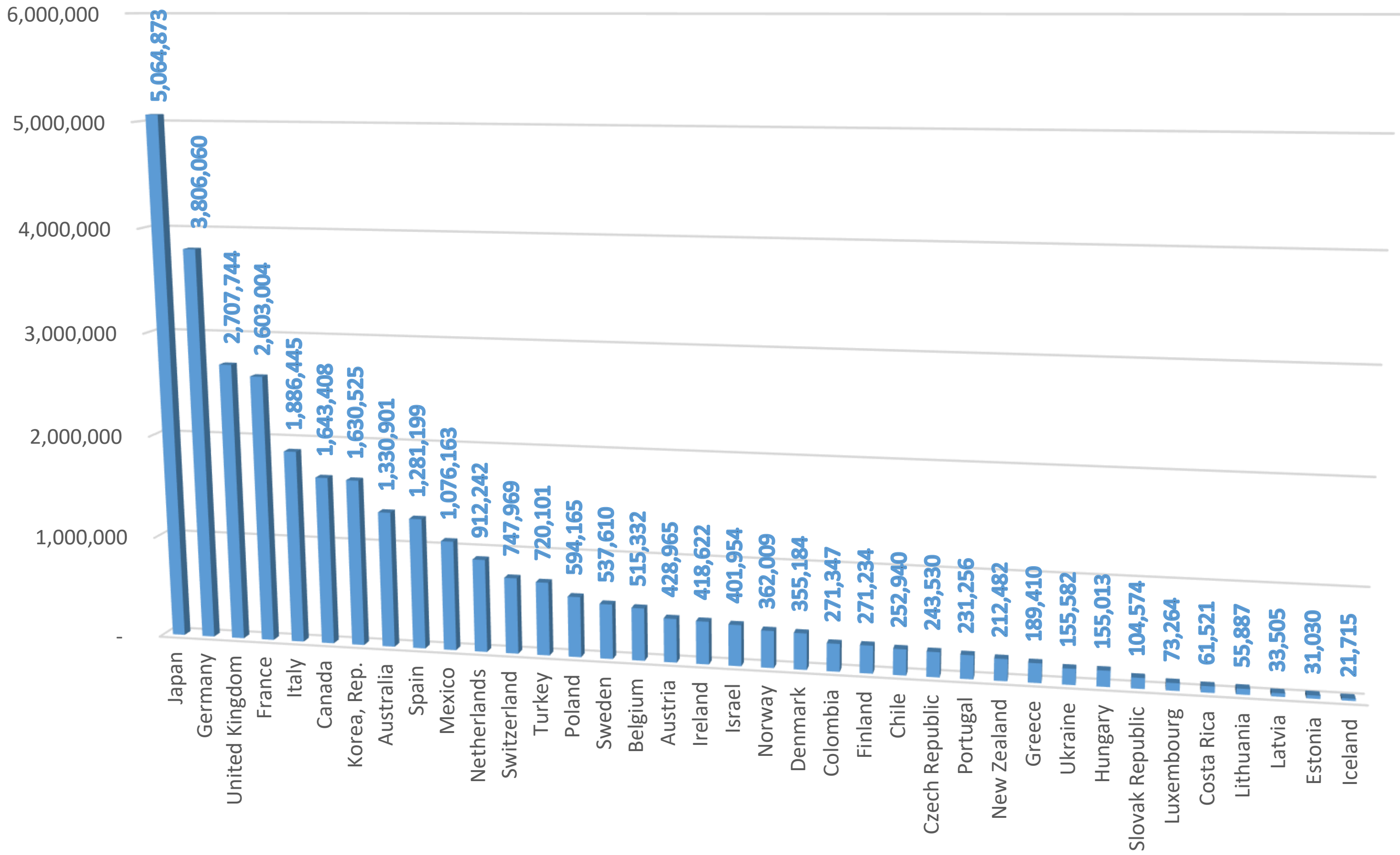
Despite Covid-19 variants and supply chain disruptions, the OECD economy expanded in 2021.

Figure 9

GDP of OECD Countries

2021

(Million US Dollars)



Source:databank.worldbank.org

In general, nations with greater GDPs tend to have higher levels of productivity measured in terms of production per hour of labor put in. There are many reasons why having high economic growth rates over an extended time encourages increased output per worker and why countries with lower growth rates tend to see decreased productivity levels.

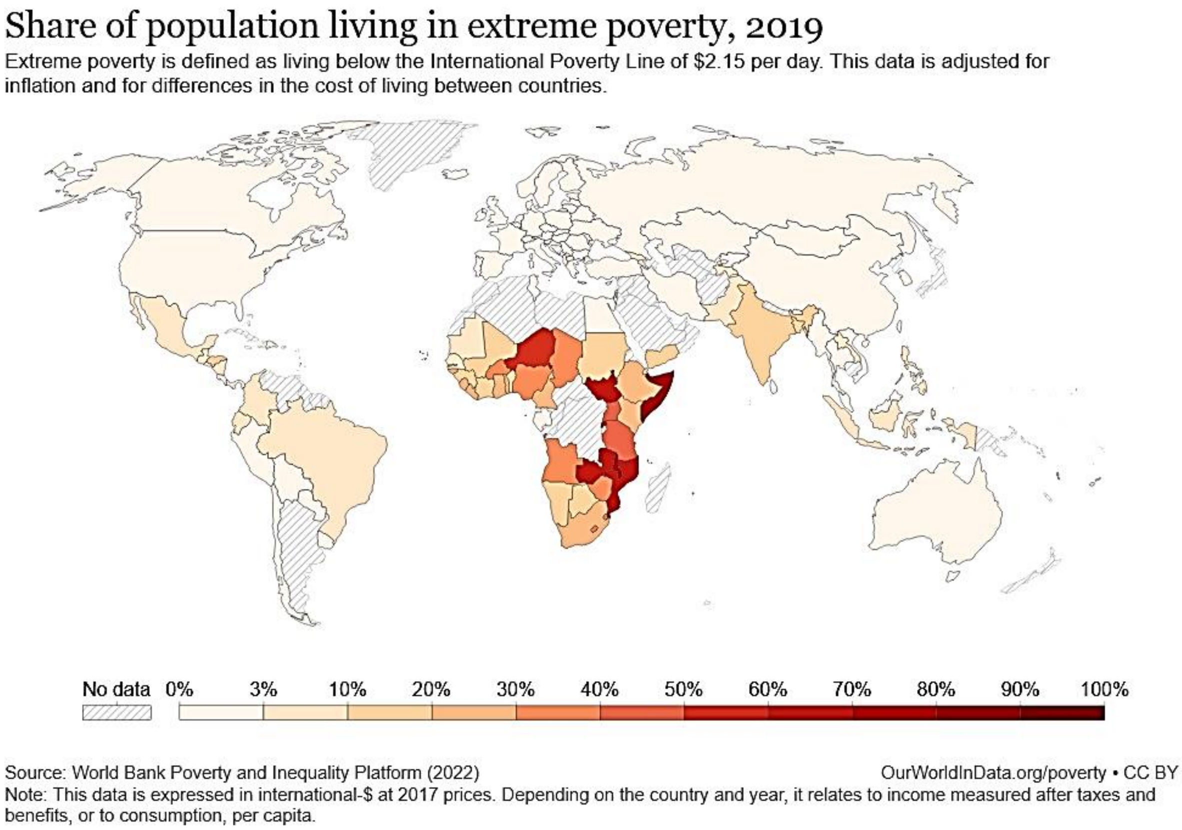
2.1.6 Poverty

There are different ways to understand poverty in and across civilizations as well as over time. Some economists have almost solely depended on income, consumption, and, to some extent, human well-being as proxies to explain and quantify an individual's situation about poverty and well-being (Wagle, 2018).

Coudouel et al. (2002) divide poverty into two classes: “Monetary” and “Nonmonetary”. Each class has some indicators as follows:

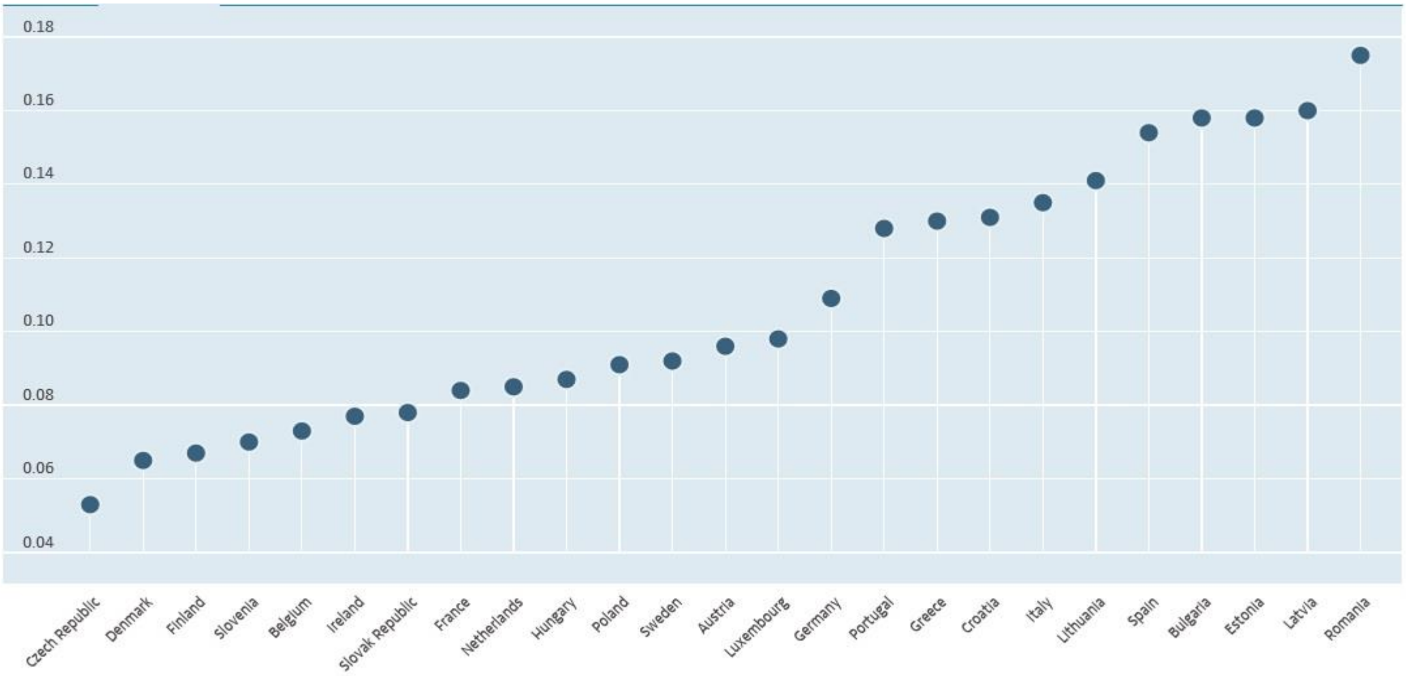
1. Monetary indicators of poverty are income and consumption.
2. Nonmonetary indicators of poverty are health and nutrition, education, and composite indexes of wealth.

Figure 10



Source: www.ourworldindata.org

Figure 11
OECD poverty rate, 2021
(Percentage of people, income distribution)



Source: https://data.oecd.org/inequality/poverty-rate.htm

2.1.6.1 Poverty measurement

Amartya Sen (1976) was the first person to inspire scholars to concentrate on the appropriate method of poverty measurement. According to Coudouel et al. (2002), three components are necessary to compute a poverty measure. First, one has to identify the relevant dimension and indicator of well-being. Second, one has to pick a poverty line, a level below which a specific household or individual would be defined as poor. Finally, one has to pick a poverty measure to be utilized for reporting for the population as a whole or for a particular segment alone. Hence, the poverty line is a dividing line between those who are poor and those who are not poor. They might be monetary (like a specific level of consumption) or non-monetary (like a certain level of literacy). Using several lines is one method that might help differentiate between the various degrees of poverty. There are two primary approaches to determining poverty lines: relative and absolute.

1. Relative poverty lines:

   These are determined concerning the general distribution of income or consumption in a nation; for instance, the line denoting poverty can be set at fifty percent of the mean income or consumption of the country.

2. Absolute poverty lines:

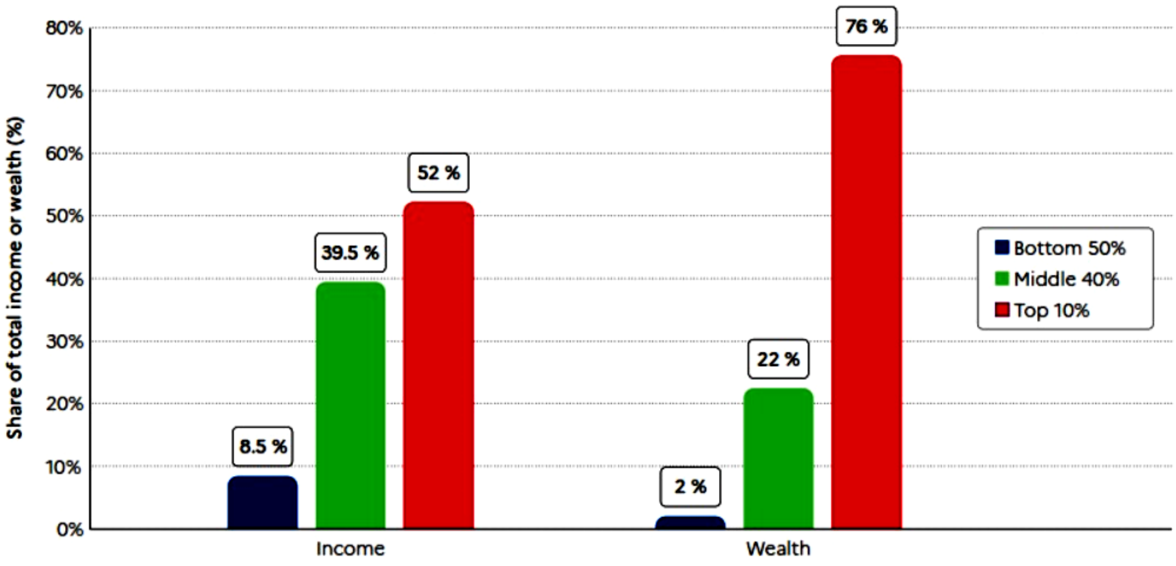
   These are based on an absolute criterion that specifies what kinds of things households must be able to depend on to fulfill their most fundamental need. In terms of monetary measurements, these absolute poverty levels are frequently based on estimations of the cost of fundamental food requirements. This refers to the cost of a nutritious basket considered minimally necessary for a normal family's health. In addition, a provision is included for fundamental needs unrelated to food. The use of an absolute poverty line, as opposed to a relative poverty line, is sometimes found to be more appropriate when taking into consideration the fact that huge portions of the people of developing nations exist on the bare minimum or less.

   "Multidimensional Poverty" is an index that measures the percentage of households in a country deprived along three dimensions –monetary poverty, education, and basic infrastructure services – to capture a more complete picture of poverty.

2.1.6.2 Poverty and inequality

Some studies, like McKnight (2019), proved that higher income inequality is correlated with higher rates of poverty and rising income inequality related to an increase in poverty.

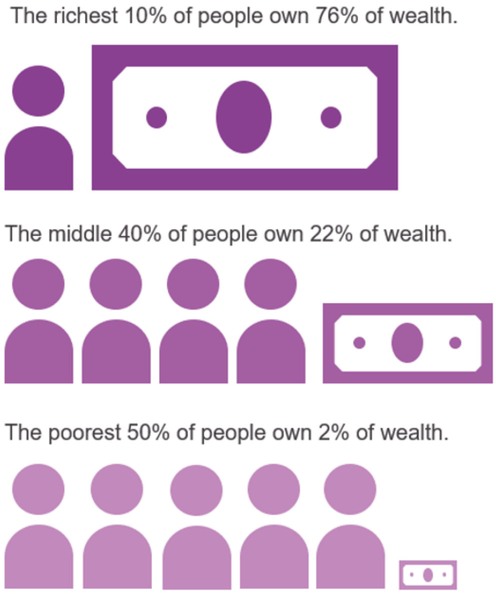
Figure 12
Global income and wealth inequality, 2021



Interpretation: *The global 50% captures 8% of total income measured at Purchasing Power Parity (PPP). The global bottom 50% owns 2% of wealth (at Purchasing Power Parity). The global top 10% owns 76% of total Household wealth and captures 52% of total income in 2021. Note that top wealth holders are not necessarily top income holders. Incomes are measured after the operation of pension and unemployment systems and before taxes and transfers.* ***Sources and series:*** *wir2022.wid.world/methodology.*

Source: (Chancel et al., 2022)

Figure 13
Richest and poorest people percentage, 2021



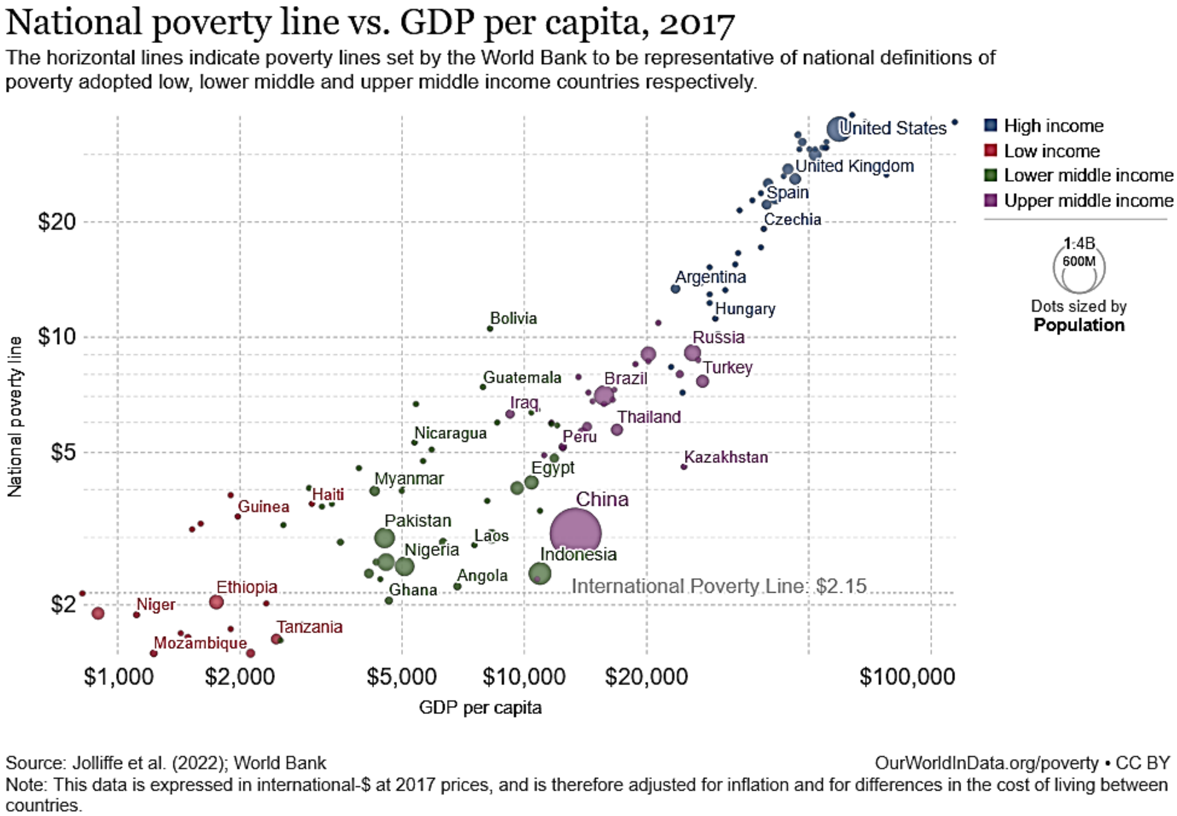
Source: (Chancel et al., 2022)

Olanrewaju Makinde (2015) proved how an increase in GDP might influence the reduction of poverty, which means there is a direct correlation between increased economic prosperity and decreased levels of poverty. Typically, higher economic growth rates are accompanied by larger levels of capital investment, which in turn results in higher levels of capital productivity. Increasing levels of capital investment may have a rather dramatic impact on overall levels of productivity. For instance, the first expansion of the oil industry in the United States was partly due to the substantial amount of cash spent on developing new drilling equipment. When it comes to investments in new technology companies or physical plants, these investments tend to make it easier for workers to produce goods and services more quickly due to improved productivity. This is because these investments tend to make it possible for workers to produce more with the same amount of effort.

Large investments may put pressure on a nation's labor market since they often result in layoffs that are not compensated for by higher salaries. This can, in turn, increase the unemployment rate among the working population. Because of this, some scholars maintain that high capital expenditures are beneficial for employment but do not necessarily result in a rise in total output levels.

2.1.6.3 Poverty and economic growth

Figure 14



Source: www.ourworldindata.org

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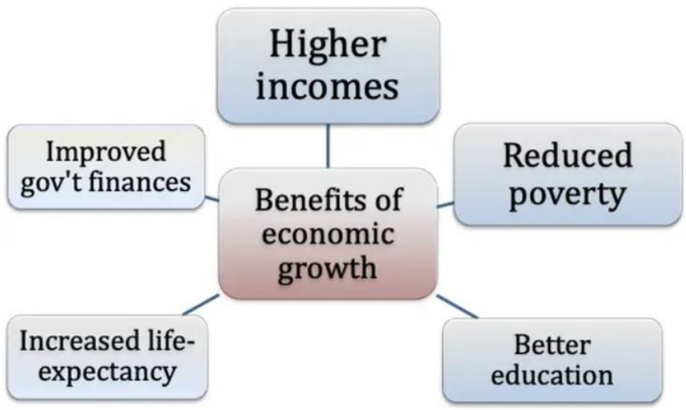
As a consequence of section 2.1, economic growth denotes a rise in real GDP, which indicates an increase in the total value of national production, income, and expenditures. The primary advantage of increased economic activity is an improvement in the quality of life. This improvement manifests in greater real wages and salaries and the capacity to direct more resources into fields such as education and medical care. (Tejvan Pettinger, 2019).

Figure 15

Benefits of Economic Growth



Source: www.economicshelp.org

2.2 Technology

In 2018, the Hungarian information and communications technology industry was responsible for five percent of the total gross domestic product; in 2019, its contribution was up by 0.7 percent; and by the end of 2020, it might reach about six percent (EMIS 2020). This industry might assist other industries, such as manufacturing, which accounts for 22 percent of the GDP. In addition, the cutting-edge applications of the IC make it easier for other industries, including wholesale and retail commerce, public administration, real estate, and transportation, to do e-business. This industry has consistently made significant contributions to the overall economic share (EMIS 2018). In the course of their study, several economists concentrated on examining the connection that exists between expanding economies and the progression of new technologies. It has been shown that the presence of competition has a beneficial effect on the implementation of new technologies since it provides the opportunity to surpass rivals (Zhu et al., 2003b). According to Rodríguez-Ardura et al. (2010) research, a detrimental connection has been shown to exist between the presence of competition and the use of online technologies, in particular.

According to Ślusarczyk (2018), the first three industrial revolutions significantly impacted industrial processes. These revolutions made it possible to increase both productivity and efficiency by making use of newly developed technologies, such as the steam engine, electrical technology, and digital technology. Developed countries have proposed some manufacturing-based stimulus policies to promote the integration of ICT industries and related advanced technologies to accelerate economic growth and seize further opportunities presented by this industrial revolution. This is done to capitalize on further possibilities presented by the industrial revolution (Yan et al., 2017)

Neoclassical economists (Solow, 1956) looked to the expansion of the labor force and the accumulation of capital as the primary contributors to economic growth. He saw the development of new technologies as an exogenous factor. The neoclassical growth model has been extended through endogenizing technological change. This was accomplished by interpreting knowledge creation as an endogenous process dependent on the quantity of human capital (Lucas, 1988) or, more specifically, human capital allocated to R&D activities (Romer, 1990).

A sizeable portion of the expansion of the economy can be attributed to technological advancements in the creative sectors. These advancements, which include devices, machines, and production modules that can independently exchange information, trigger actions, and control other similar processes, make it possible to create an intelligent business environment (Weyer et al., 2015).

To provide an accurate evaluation of the influence of ICT, we must first comprehend the role that they play in the expansion of the economy. This may be accomplished by demonstrating that information and communications technology open up prospects for commercial activity and also by using manufacturing functions. For instance, computers may enhance their productivity by raising the overall quality of their output while simultaneously lowering the amount of money they spend. Take, for instance, the practice of 3D printing, which had not even been conceived of a few decades before the present day, although it is now used by big corporations operating in various fields. Nevertheless, this is only one illustration of what computers have been capable of doing in previous years; the list is far longer than this. If we use computers better, we can produce a product more quickly than manually, saving time and money.

Figure 16

Industry 4.0 Consequences

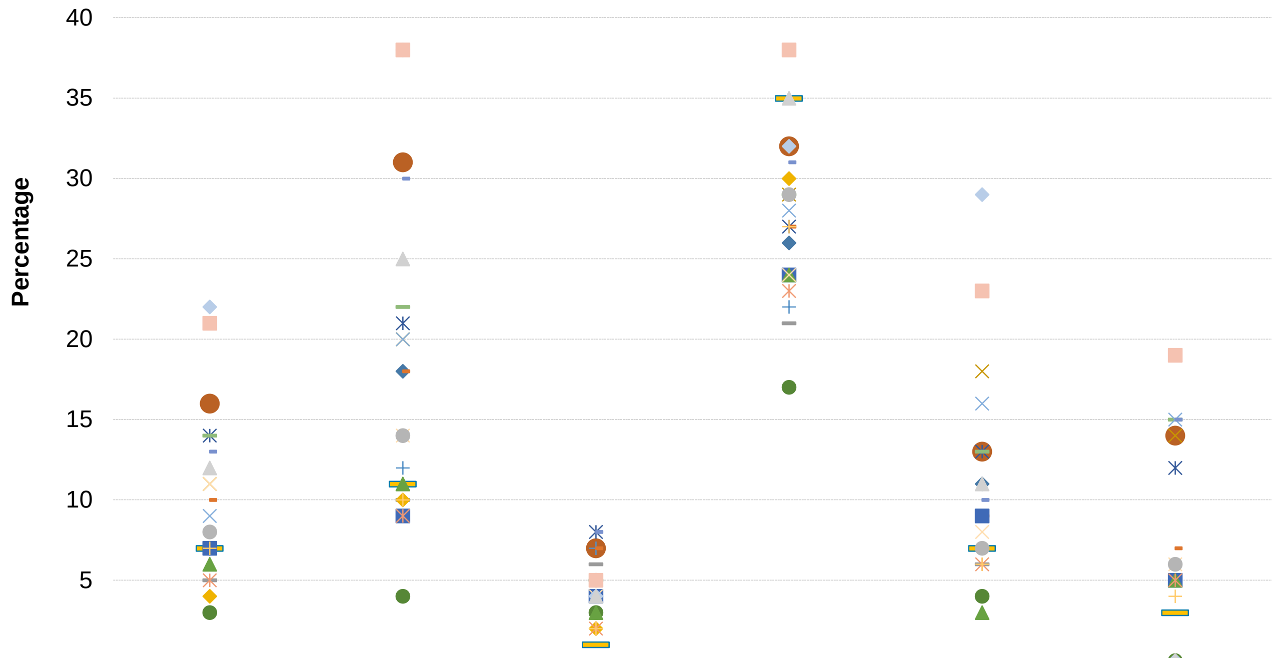
Source: www.ourworldindata.org

Table 2
The contribution of ICT-producing industries to economic growth in OECD countries, 1995-2007

	Productivity growth in:		% due to ICT
	Business sector	ICT industries	
Australia	0.02	0.01	40
Austria	0.58	0.13	23
Belgium	-0.37	0.15	> 100
Czech Republic	0.71	0.19	27
Denmark	-0.39	0.15	> 100
Spain	-0.77	-0.00	0.4
Finland	1.44	0.50	35
France	0.43	0.21	49
Germany	0.41	0.29	69
Hungary	2.21	0.60	27
Ireland	0.78	0.25	32
Italy	-0.48	0.12	> 100
Japan	0.23	0.23	100
Netherlands	0.40	0.19	48
Slovenia	0.23	0.15	66
Sweden	0.66	0.71	> 100
United Kingdom	0.28	0.19	67
United States	0.59	0.35	59

Source: (Spiezia, 2012)

Table 3
Impact of ICT on tasks and skills in OECD countries,
(Percentage of individuals)
2018



	Individual's main job tasks changed as a result of the introduction of new software or computerised equipment	Individuals had to learn how to use new software or computerised equipment for the job	Individuals needed further training to cope well with the duties relating to the use of computers, software or applications at work	Individuals' skills correspond well to the duties related to the use of computers, software or applications at work	Individuals had the skills to cope with more demanding duties related to the use of computers, software or applications at work	Individuals were involved in choosing, modifying or testing the software or computerised equipment used at work
Belgium	7	18	4	26	11	0
Czechia	7	11	1	35	7	3
Denmark	16	31	7	32	13	14
Germany	11	20	5	29	18	14
Estonia	14	21	8	27	13	12
Greece	3	4	3	17	4	0
Spain	7	12	7	22	7	5
France	10	18	7	27	9	7
Italy	5	10	6	21	6	0
Latvia	4	10	2	30	7	0
Lithuania	7	9	4	24	9	5
Luxembourg	14	22	5	29	13	15
Hungary	6	11	3	24	3	5
Austria	9	20	5	28	16	15
Poland	5	9	2	23	6	5
Portugal	11	14	4	24	8	6
Slovenia	8	14	5	29	7	6
Slovakia	7	10	2	27	6	4
Finland	13	30	8	31	10	15
Iceland	22	38	4	32	29	0
Norway	21	38	5	38	23	19
United Kingdom	12	25	4	35	11	0

** 0 means there is no data for this country this year.*
Source: Eurostat (online data code: ISOC_IW_IMP$DEFAULTVIEW)

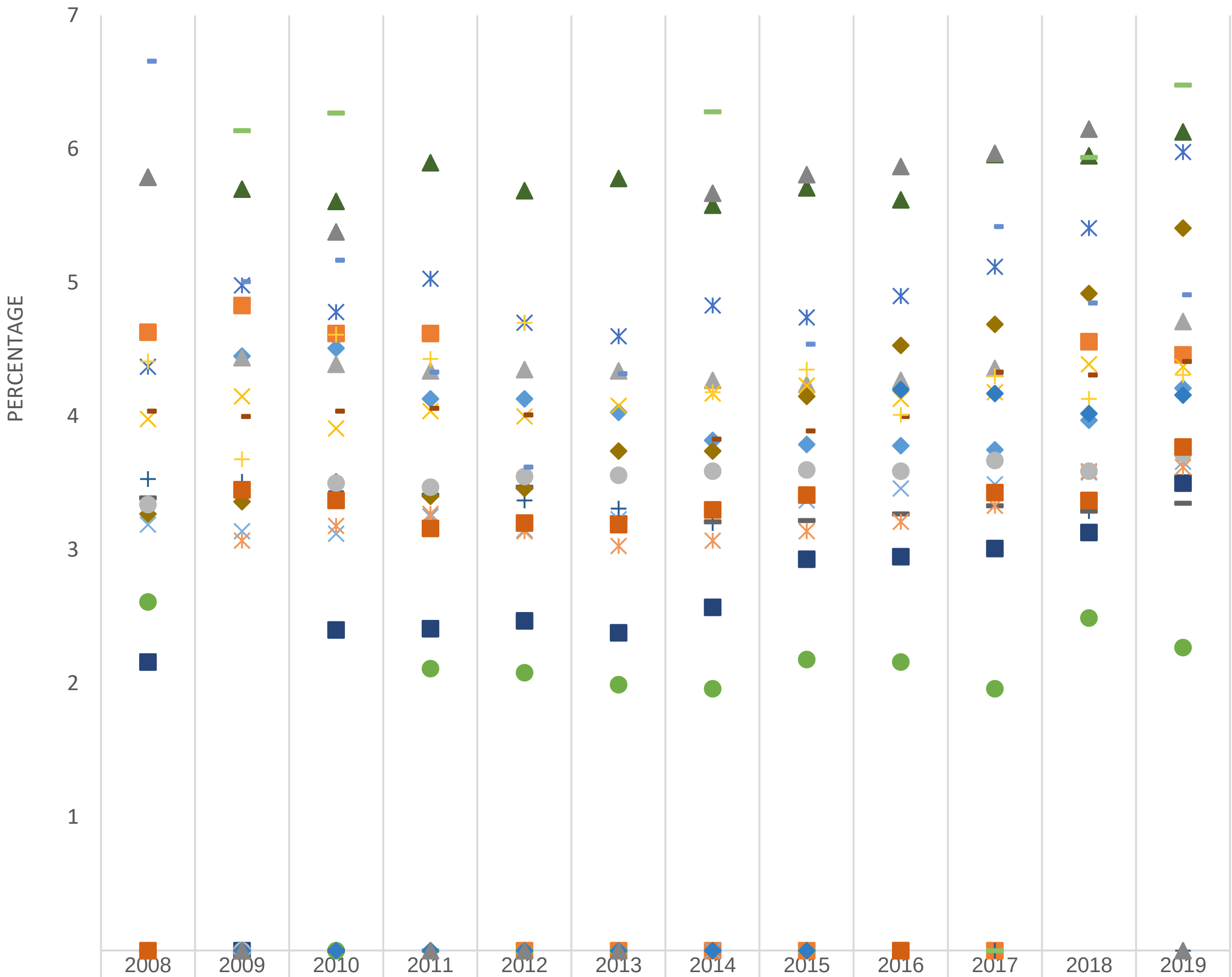
Information and Communication Technology improve Access to information is made easier because of advancements in telecommunications and information technology, which in turn boosts economic output (Levine, 1997).

Changes have been made in manufacturing, supply chain management, marketing, and other aspects of the business due to the rapid advancements in information and communication technology (ICT). In today's industrial assembly lines, information and communications technology (ICT) are becoming an increasingly vital component of material handling, often known as MHE. Material handling systems such as the Automated Storage and Retrieval System (ASRS) are designed to increase the production system's overall throughput by lowering the time spent selecting, storing, and retrieving goods.

The adoption of information and communications technology is another one of the most serious global difficulties that all industrial sectors throughout the globe are now facing. This is because information and communications technology allows businesses to increase their productivity and efficiency by incorporating new technologies into their production processes. When viewed from a global perspective, businesses cannot advance at their own pace, which is especially true in developing countries due to a lack of financial resources. This inability to stimulate economic growth has significantly impacted both developing and rich countries (Nagy et al., 2018). This deficiency in financial resources is the consequence of several issues, including, but not limited to, poor productivity, which is the direct effect of bad product quality, a failure to embrace new technologies and inefficient manufacturing.

ICT is known for having superior levels of performance, which is why many businesses now require their use. Despite this, the conventional forms of information and communications technology (ICT), hardware and software continue to hold the majority of sales to satisfy the requirements of maximum profitability (Postelnicu & Dabija, 2015). Furthermore, it influences the whole supply chain to ensure production efficiency, demonstrating that adopting cost-effective technology plays a significant role in the global sales of material handling equipment (Pereira & Romero, 2017).

Table 4
Percentage of the ICT sector on GDP in OECD countries,
2008-2019



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Belgium	0	4.45	4.51	4.13	4.13	4.03	3.82	3.79	3.78	3.75	3.97	4.21
Czechia	0	4.44	4.39	4.34	4.35	4.34	4.27	4.24	4.27	4.36	4.56	4.71
Denmark	4.63	4.83	4.62	4.62	0	0	0	0	0	0	4.56	4.46
Germany	3.98	4.15	3.91	4.04	4	4.08	4.17	4.23	4.13	4.18	4.39	4.37
Estonia	4.37	4.98	4.78	5.03	4.7	4.6	4.83	4.74	4.9	5.12	5.41	5.98
Greece	2.61	0	0	2.11	2.08	1.99	1.96	2.18	2.16	1.96	2.49	2.27
Spain	3.53	3.51	3.44	3.4	3.37	3.31	3.2	0	0	0	3.29	0
France	4.04	4	4.04	4.06	4.01	0	3.83	3.89	4	4.33	4.31	4.41
Italy	3.39	0	0	3.41	3.47	3.24	3.21	3.22	3.27	3.33	3.29	3.35
Latvia	3.27	3.36	3.51	3.4	3.46	3.74	3.74	4.15	4.53	4.69	4.92	5.41
Lithuania	2.16	0	2.4	2.41	2.47	2.38	2.57	2.93	2.95	3.01	3.13	3.5
Hungary	5.79	5.7	5.61	5.9	5.69	5.78	5.58	5.71	5.62	5.96	5.95	6.13
Austria	3.19	3.14	3.12	3.25	3.15	3.23	0	3.37	3.46	3.49	3.58	3.66
Poland	0	3.07	3.18	3.27	3.14	3.03	3.07	3.14	3.21	3.33	3.59	3.62
Slovenia	3.34	0	3.5	3.47	3.55	3.56	3.59	3.6	3.59	3.67	3.59	3.72
Slovakia	4.41	3.68	4.61	4.43	4.7	0	4.18	4.35	4.01	4.3	4.13	4.31
Finland	6.66	5.01	5.17	4.33	3.62	4.32	0	4.54	0	5.42	4.85	4.91
Sweden	0	6.14	6.27	0	0	0	6.28	0	0	0	5.94	6.48
Iceland	0	0	0	0	0	0	0	0	4.2	4.17	4.02	4.16
Norway	0	3.45	3.37	3.16	3.2	3.19	3.3	3.41	0	3.43	3.37	3.77
United Kingdom	5.79	0	5.38	0	0	0	5.67	5.81	5.87	5.97	6.15	0

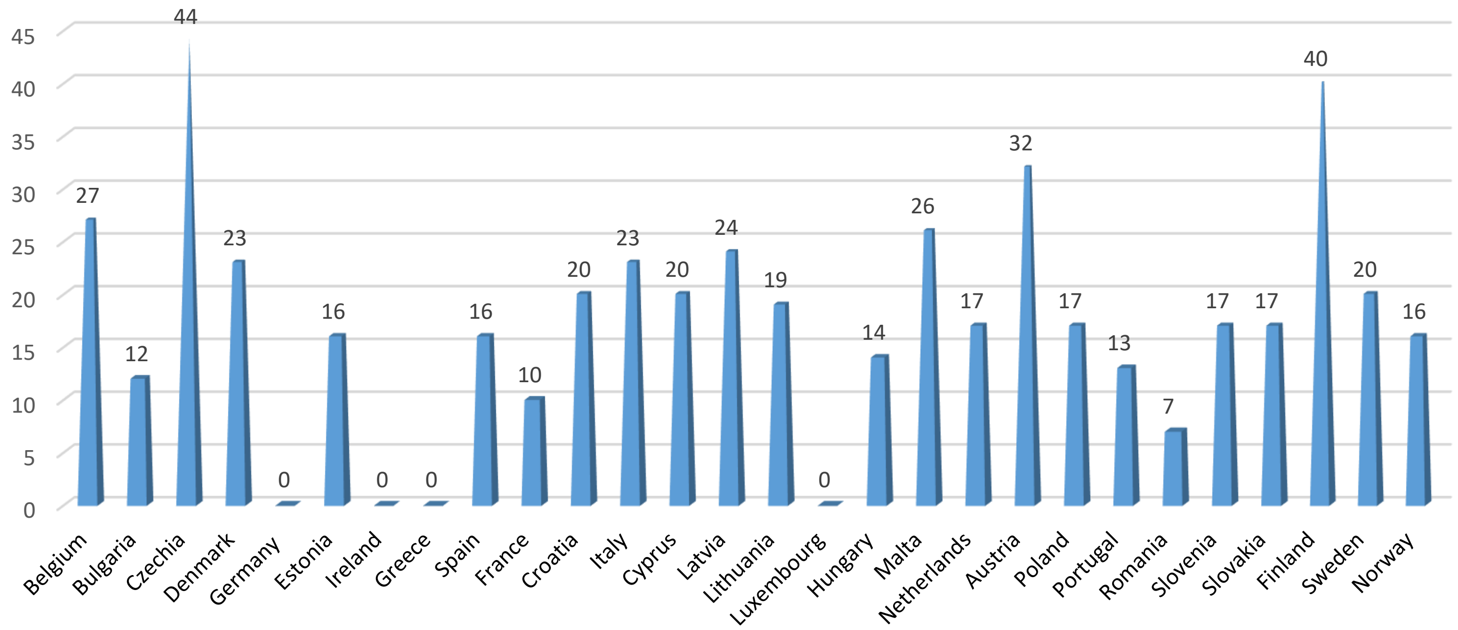
** 0 means there is no data for this country this year.*
Source: Eurostat (online data code: TIN00074)

The Internet of Things (IoT), which encompasses every facet of human existence in today's world, has a considerable impact on people's quality of life.

The Internet of Things (IoT) is now one of the technologies with the greatest potential to affect future economic expansion due to its rapid rate of development. It is accessible to all sectors, including business and industry, home appliances, and consumer electronics, and this accessibility has contributed to the company's success. The Internet of Things has applications in a wide variety of industries, including but not limited to transportation, health care, home automation, and smart living.

The Internet of Things (IoT) has a profound impact on both the lives of individuals and the operations of organizations, and it will continue to spark innovation in the years to come. It is anticipated that over the next decade, it will advance tens of billions of linked devices worldwide, which will produce multi-trillion dollars of economic value across numerous sectors, building the basis of an interconnected world, also known as the Internet of Everything (IDC Forecasts, 2017). The Internet of Things (IoT) is a pattern that examines a variety of things or objects that may communicate with one another across wireless or wired connections to work together with other machines to produce new things of value. The Internet of Things is a game-changer for the Internet. Objects may archive information compiled by other data or machines, or they can be components of multiplexed things.

Figure 17
Percentage of companies used interconnected devices or systems that can be monitored or remotely controlled via the internet in OECD countries, 2020



** 0 means there is no data for this country this year.*
Source: Eurostat (online data code: isoc_eb_iot)

Today, the number of tangible things that can be linked to the Internet is growing as a result of the miniaturization of electronic components and their introduction into new industries. The Internet of Things (IoT) is essentially an extension of digital technology that includes connectivity with common items, things that have sensors, or intelligent devices implanted inside them. As a result of this trend, organizations are shifting their focus from systems to services, which marks another paradigm change for business operations. Because of this movement, there will be a significant change in how commerce is conducted via both online and physical encounters.

The Internet of Things (IoT) comprises many diverse things linked to one another through a network. As a consequence, the Internet of Things has the potential to have a detrimental impact on society; for instance, it is usual for individuals to locate their automobiles using GPS technology via their phone or watch, no matter where they are. This indicates that there is no private space available. As a result, everything that must be done to transform the Internet of Things into something useful must be done perfectly.

The Internet is not merely a network of computers but has also developed into a network of devices of many shapes, sizes, and types. For example, automobiles, smartphones, home appliances, toys, cameras, medical instruments and industrial systems, animals, people, and buildings are all examples of connected information that is based on predetermined protocols to accomplish intelligent reorganizations, positioning, tracing, safety, and control. Even individualized, real-time, online monitoring; online upgrades; online supervision and administration of processes; and so on (Patel et al., 2016)

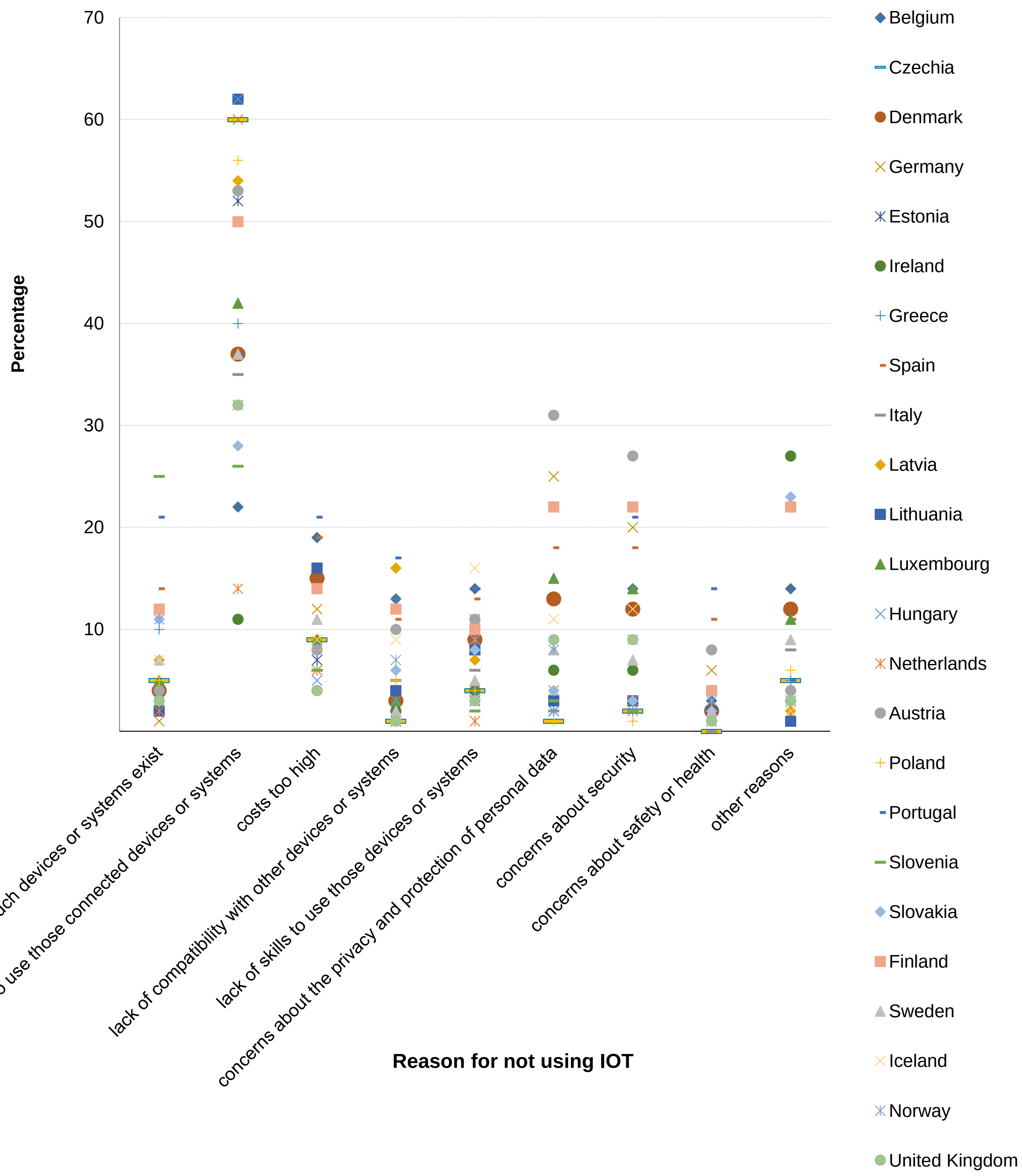
The Internet of Things (IoT) is based on the idea that mechanical, electrical, and data processing technologies may be combined to create a network connection between disparate physical objects.

The Internet of Things (IoT) uses networked sensors to monitor different elements of the environments in which diverse things are located. Real-time data processing and communication occur among objects and devices integrated with other devices. These sensors are deployed to measure the variables about condition or performance variables that are occurring at or near a machine or object. These variables include temperature, pressure, humidity level, vibration, and pressure changes over time, among other things. The Internet of Things permits the direct control of physical items over the Internet and makes it feasible for machines to have meaningful conversations with one another.

The Internet of Things (IoT) makes an ongoing investigation of linked gadgets possible. Studying the Internet of Things is important because many intelligent devices are linked to the internet system. These objects may be utilized to better enterprises, organizations, governments, and individuals. IoT will also impact our lives, either for the better or the worse, depending on whether revolutionary developments occur today. The Internet of Things (IoT) is a technology for interconnectivity that embeds instrumentation on hardware and software onto equipment that is network-connected. This technology is used in all areas of the economy, including energy (through the use of smart meters), healthcare (through the use of wearables), transportation (through the use of linked cars), and defense. The growth of the Internet of Things (IoT) has brought potential concerns regarding security, privacy, interoperability, and scalability. However, these issues may also give chances for prospects for better experiences via monitoring and monetization.

The Internet of Things (IoT) will enable businesses to monitor the activities in their locations in real time. In the current implementations, computers are responsible for disseminating information over the internet; nevertheless, this method only enables businesses to learn that anything may be wrong when actual attackers get into their systems. The utilization of big data is the long-term answer to the problem. This will ensure that if anything goes wrong, it will not just be a rumor but will instead be able to be acted upon promptly with an exact report of what has occurred. IoT fields will surely mature and influence human life in unbelievable ways over the next decade (Yusuf Perwej et al., 2019)

Table 5
Barriers to the use of IoT in OECD countries,
2020



Source: Eurostat (online data code: ISOC_IIOT_BX$DEFAULTVIEW)

1. I didn’t know such a system or device existed:

In Italy and Czechia, more than 20% of the respondents did not know the usage of IOT. In Spain, Finland, Norway, Slovakia, and Greece, the percentages of respondents are between 10 and 15, and in the remaining countries, less than 10% of the audiences are not familiar with IOT.

It means that in most countries, people know the usage of IOT very well.

2. No need to use those connected devices or systems:

This factor is in the first rank of the barriers to using IOT. Lithuania and Germany are in the top rank in this class (higher than 60%). Ireland and the Netherlands have the lowest percentage (10% to 20%).

3. Costs too high

In all the countries, less than 20% of respondents express that the high cost of the internet is a barrier to using IOT (except Portugal). Belgium and Spain are close to 20%. Lithuania, Denmark, and Finland are around 15%. Sweden and Germany are near 10%, and the others are below 10%. As a result, this item does not have a high effect on using IoT in the selected countries.

4. Lack of compatibility with other devices or systems:

In most countries, only 10% or less chose this factor as a barrier to the use of IoT. In a few of them, such as Portugal, Latvia, Belgium, Finland, and Spain, the percentages of the respondents who chose this item are 18% to 10%. Thus, IoT is flexible and can adapt to devices or systems.

5. Lack of skills to use those devices or systems:

The same scenario as the previous factor (No.4) happened, which means learning how to use IoT is not complicated. The important point is that Germany is the most difficult country to learn IoT. The reason could be “the huge number of companies and the vast industries in this country as one of the main industrial countries in the world”.

6. Concerns about privacy and protection of personal data

More than 30% of respondents in Austria selected this factor as a barrier. It is between 20% and 25% in Finland and Germany. In other countries, it is less than 20%.

7. Security concerns:

It is exactly like the previous factor (No.6). Austria, Germany, and Finland are in the top rank. The only difference between No.6 and No.7 is that the percentage of respondents decreased by about 5% in No.7 (compared with No.6)

8. Concerns about safety and health:

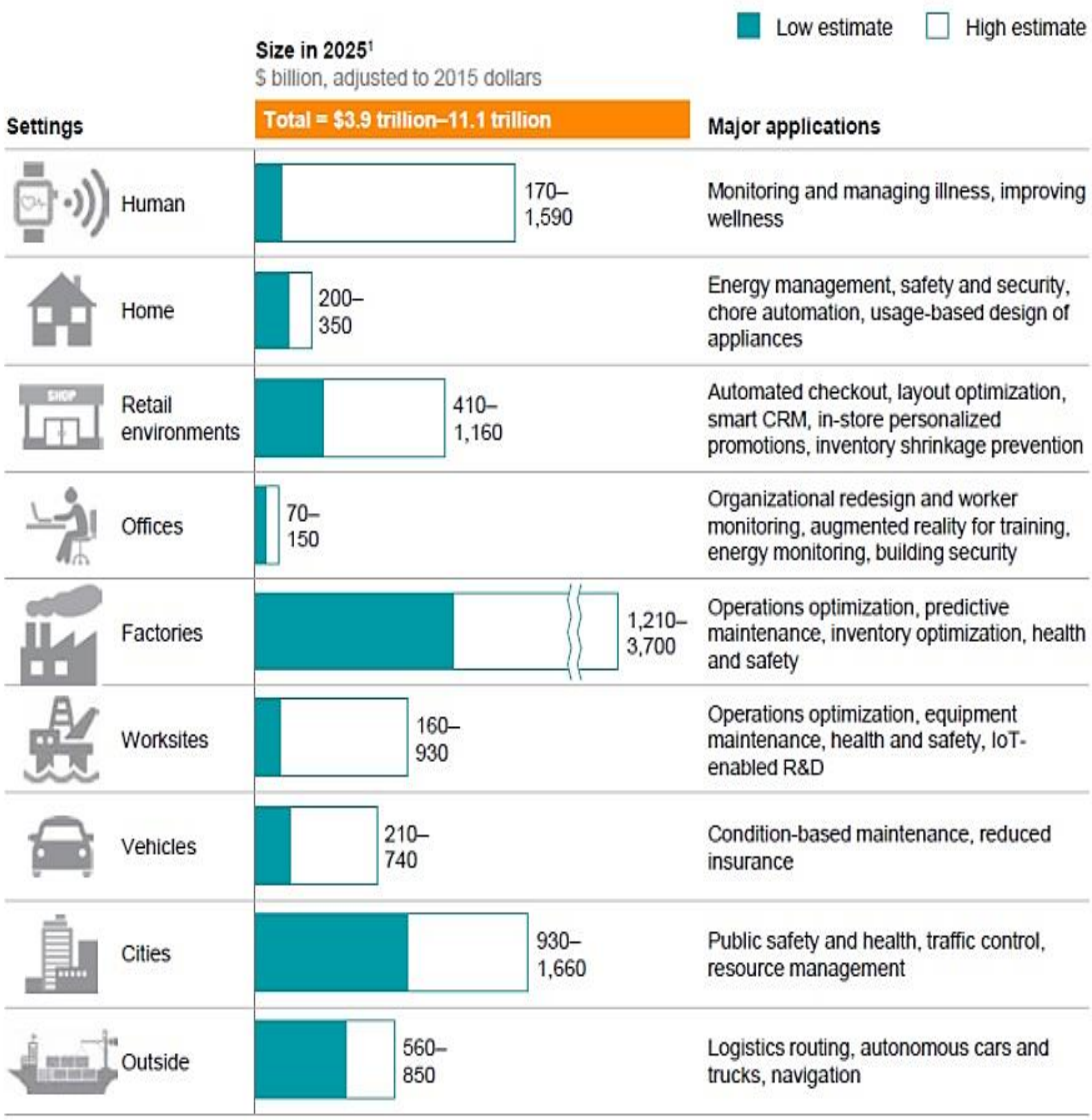
As the first group of countries, in Portugal and Spain, the audiences chose 12% to 15%.

The second group belongs to Austria, Germany, and Finland, which is 5% to 8%, and the 3rd group is the remaining countries where the respondents chose this factor less than 5%, which can be considered a barrier to using IoT. Thus, It can be strongly claimed that "using IoT is safe".

9. Other reasons:

In Ireland, Slovakia, and Finland, 30% of respondents agree with this item as a barrier. In Belgium, Denmark, and Luxemburg, it is 20% to 25%. In the other countries, it is less than 20%.

Figure 18
The Potential of Global IOT Economic Impact
by 2025



Source: (Bashari Rad & Abdilaziz Ahmada, 2017)

1. Human:

The potential of IoT to improve people's wellness and monitor and manage illness is estimated at 170 billion to 1.59 billion USD. It means a noticeable part of people's health will be managed by IoT soon. So, health policymakers need to pay attention to the crucial role of IoT.

2. Home

Based on this research, the effect of IoT on energy management, safety and security, core automation, and usage-based design of appliances is supposed to be 200 to 350 billion USD by 2025.

IoT brings us the facility to control the energy and monitor the safety of our homes when they are not there. It is a great possibility.

3. Retail environments:

A professional CRM system enables us to encourage our customers to buy our products repeatedly, make them our “loyal customers, " and motivate them to introduce our products to others. A successful CRM system would not be implemented without an efficient IoT. So, IoT is a prerequisite of CRM. There is the same story for an inventory system.

4. Offices:

Although the effect of IoT on offices is estimated at 70 to 150 billion USD, it is clear that the coefficient of this item is high because it is an essential factor for the other activities of an enterprise.

5. Factories:

As we see in the figure, the effect of IoT on industries has the highest rank among the other factors and is estimated at 1,210 to 3,200 billion USD, which is a great effect, and we can claim it as a REVOLUTION IN INDUSTRY.

6. Worksites:

The effect of IoT on worksites -like the impact of IoT on factories- is very important—especially the influence of IoT on R&D activities, which works as the brain of a company. Hence, implementing IoT in the R&D department leads the company to be more creative, develop a variety of products, expand the company projects, and finally increase the profit.

7. Vehicles:

Using IoT in vehicles decreases accidents, which leads to less insurance.

8. Cities:

Since the beginning of the 21st century, many things have been changed. If we compare our lifestyle with our grandfathers’ daily routine, we understand that problems such as traffic, pollution, extra weight due to inactivity, etc., appear in our lives and are common today. IoT reduces these problems and enables us to manage our lives in this condition.

9. Outsides:

Everybody knows the positive effect of IoT on navigation and transportation now, which increases productivity in this sector. A logistics company cannot provide good service to its customers without IoT.

2.2.1 Internet access in schools

According to studies conducted by the OECD organization in the last few years, the "first digital gap," which refers to variations in access to computers among pupils aged 15, has narrowed in most nations that are members of the OECD. Students now have access to computers and internet connections at school and home to a greater extent than ever before. Access to computers has virtually reached a state of universality in the majority of these nations. However, significant disparities exist across nations regarding the number and quality of devices that can be accessed, the age at which children are introduced to computers for the first time and the level of experience that can be obtained via their use. In some of the countries that took part in the OECD's 2022 Programme for International Student Assessment (PISA), for example, a significant number of students aged 15 reported that they had only recently used the Internet if they had ever used it at all. On the other hand, the majority of students in other countries stated that they had started using computers at the age of 6 or younger. There are also disparities in how boys and girls utilize computers, electronic gadgets, and other forms of information and communication technology for both recreational and educational purposes. In particular, girls tend to score better than boys in reading, and this holds for both paper-based assessments and computer-based testing. However, the performance difference between the sexes is lower in digital reading, mostly because males prefer to perform better on computer-based tests. According to the findings of the research, students' success in reading print texts typically parallels their skill in reading digital materials. This suggests that students cannot flourish in online reading without also being able to comprehend and draw conclusions from printed texts. An empirical study was conducted by Aristovnik (2012) on the effects of information and communications technology (ICT) on educational performance and the effectiveness of education in many nations that are members of the OECD and the EU. According to the findings of the study, the majority of the nations that are being considered have a significant amount of untapped potential for enhancing their educational outputs and outcomes, as well as for increasing their ICT efficiency and productivity performance.

The advancement of communication technology has had a considerable impact on education, mostly because it increases the efficiency of the teaching staff.

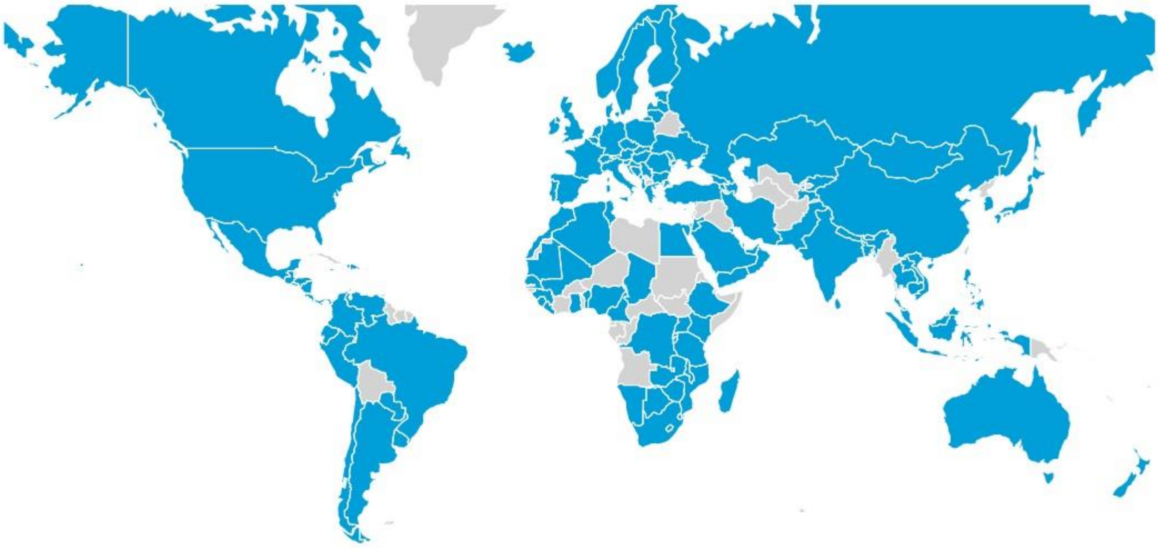
It is common knowledge that some schools have started offering internet connection to pupils to increase student learning; yet, the question remains as to whether or not this strategy is truly effective in achieving the desired outcome.

It is, of course, extremely essential to understand how pupils acquire the skills necessary for digital literacy, as well as the potential effects of cyberbullying and online predators on students. as well as finding out who is responsible for providing internet for schools and what some of the difficulties associated with enforcing such restrictions are.

Students need to have some level of digital literacy abilities. This cannot be stressed enough. The capacity to utilize digital technology to generate, communicate, and comprehend information is meant by "digital literacy." This suggests that students need to have a working knowledge of how technology works, as well as an understanding of how it may be utilized successfully and how it affects their learning. Pupils will probably be able to develop their digital literacy abilities if they have access to the internet in some way at school. The concept of using the internet while at school is still relatively unfamiliar for many children (compared to how they use it at home). Already, having access to digital resources on campus has brought about many positive outcomes. Thanks to the internet and other online resources, students and instructors can access a plethora of material relevant to the curriculum's subject matter. Kids who use the Internet for educational reasons demonstrate better levels of accomplishment compared to students who do not utilize the Internet for educational purposes, as stated by Pew Internet and American Life Project (2001). This is due, in part, to the abundance of websites and online resources that are readily available for use in the classroom by both instructors and students. These resources can include interactive activities and games, databases, videos, audio clips, images, simulations, testing programs, and virtual labs, among other things. Students can readily obtain extra material relating to class work or research subjects when they have access to the internet in school during free time or classroom times when a structured learning activity is appropriate (such as a lab). This access is provided throughout school hours.

On the other hand, although the advantages of providing pupils with access to digital media have been discussed in the previous section, what about the drawbacks? The internet is a fantastic instrument for education, but it also has the potential to be a venue for malicious behavior like cyberbullying and the presence of online predators. "Students who use computers at home have grown more prone to harass others online," claims research published by the National Center for Technology in Education (NCTE). Students who frequently use computers during their teaching time at school should find this quite unsettling information. However, educators must be aware of how social media tools are used in their classrooms. This will allow them to more effectively monitor how students are using these platforms.

Figure 19
Global availability of Internet access in schools
2017



Source: World Economic Forum (2018)

* *62.39% of all countries have available data for Internet access in schools in 2017*

2.2.1.1. Internet in Schools and Economic Growth

Scholars (Devarajan et al., 1996; Eriçok & Yılancı, 2013; Psacharopoulos & Patrinos, 2018) have shown that having access to the Internet in schools is associated with a higher rate of economic development in countries that are members of the OECD. In addition, Karaçor et al. (2018) concluded that having internet access in schools has a favorable impact on economic development and improves the level of educational quality, both of which are required for increased productivity. On the other hand, these effects may not be felt in many instances until a much longer time has passed. Additionally, Kho et al. (2011) performed research on the effects of Internet access in schools in Peru between the years 2007 and 2017, comparing schools that had access to the Internet with schools that either did not have access to the Internet or that had gotten it at a later period. They observed that schools with internet connection reported only a somewhat greater performance of children on standardized math exams, with standard deviations ranging between 0.04 and 0.08 throughout the first 18 months of the study. On the other hand, the gap that existed between students who had and did not have access to the internet widened with each passing year, becoming more noticeable. Several other causes were cited as reasons for the expanding influence of school connectedness. One of the most important factors was the gradual increase in the number of teachers hired over time who had prior experience and education in the operation of personal computers and the internet, and who were consequently able to more successfully incorporate the use of digital tools into their lessons. There was a 2.1 percentage point increase in the likelihood that a school would have a teacher who was trained in computers up to one year after connecting to the internet, and there was a 9.6 percentage point increase in that likelihood up to five years later.

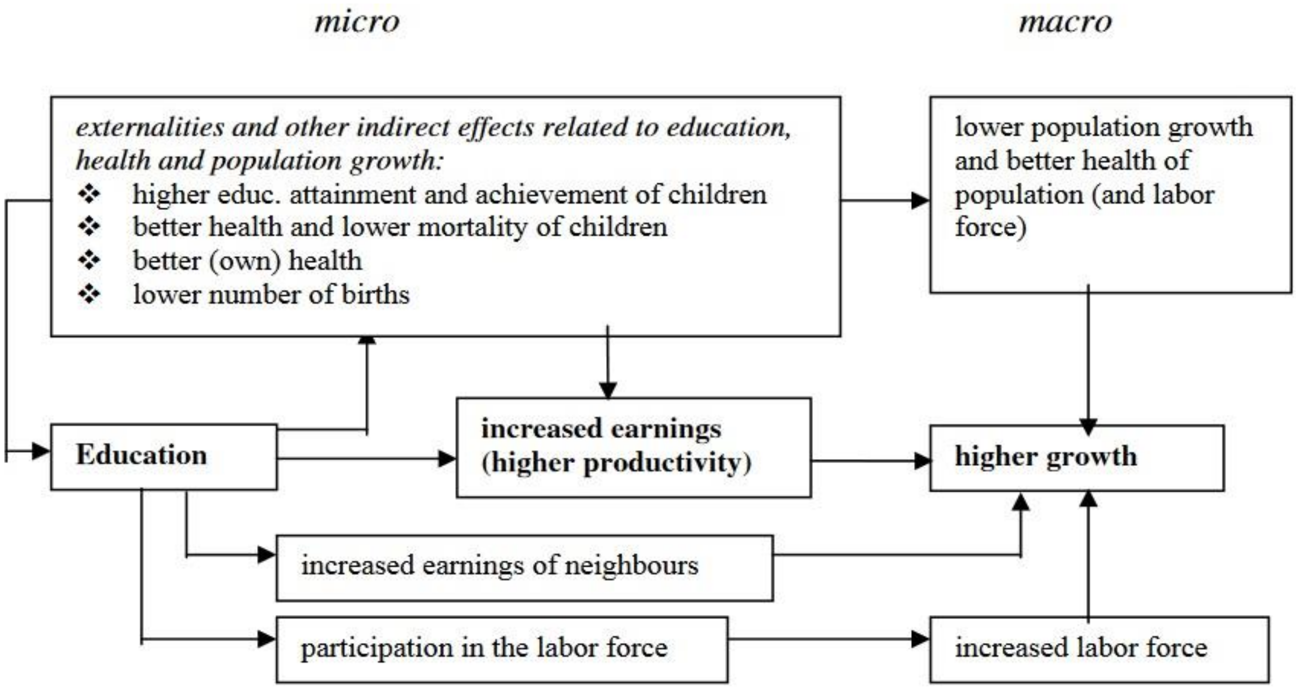
According to Hanushek & Kim (1995), the rapid expansion of new digital technologies of learning– both as blended learning with teachers and technology as well as standalone approaches– suggests that many of the previous decisions, both on access and quality, might rapidly lead to more productive outcomes. In addition, the Economist Intelligence Unit (EIU), which Ericsson sponsored in support of UNICEF, indicated that linking schools to the Internet may increase GDP growth by up to 20 percent as a restricted broadband connection. In these nations, greater internet penetration gives a chance to expand the abilities of teachers cost-effectively. This is especially important when there is a lack of competent instructors since it is during this time that this opportunity is most critical. In this context, digital technologies can also support teachers by providing them with additional tools and, through blended learning approaches, freeing up time for them to focus on teaching rather than on administration. As access to education expands worldwide, there is a risk that the teaching profession could become unmanageable with growing class sizes. In addition, having access to the internet helps instructors direct their attention where it is most needed by giving real-time information on their students' performance.

Internet connectivity in schools is not the only factor that may boost economic growth; nonetheless, it is an effective way of promoting the intense and creative use of technology for all students. This is the case, although internet access in schools is not the only factor. Nations still on the path to economic growth need a solid understanding of the benefits of investing in internet connections in educational institutions.

It is crucial to have a global perspective when examining the relationship between access to the Internet and GDP per capita. This link is not as straightforward as one would assume; for example, some countries like Niger have a low GDP per capita but high levels of internet connectivity, while other nations have high levels of both criteria.

As shown in Figure 20, according to Michaelowa (2000), the effects of education on productivity are illustrated from micro and macro perspectives. Based on this figure, health and population growth are two factors that lead to making a labor force for an economy.

Figure 20
Economic returns to education



Source: (Michaelowa, 2000)

2.2.2 Availability of the latest technologies

Industry 4.0 is an extensively discussed and researched complex technological system. It has a significant influence on the industry because it introduces relevant advances related to smart and future factories. Industry 4.0 may eventually represent a fourth industrial revolution (Pereira & Romero, 2017). Scholars have just recently found how businesses are coping with the phenomena of Industry 4.0, the instruments to assist their operations, and what significant and critical issues they encounter during the adoption of ICT (Nagy et al., 2018). According to Zhu et al. (2003a), rivalry has a beneficial impact on the implementation of new technologies that may be discovered. This is because rivals are allowed to be outperformed by new technologies.

A successful adaptation requires adjusting to technological advances to reallocate resources and accommodate the growing requirements of emerging nations (Adao et al., 2017). These nations can simply adopt the suitable and essential techniques already available on the market and implement them across other countries (Nagy et al., 2018). Additionally, the scholars suggested that the positive effect of the most recent technological adoptions is robust in the case of developing countries (Meyer & Meyer, 2016) manufacturing (Máté, 2014), and other knowledge and technology-intensive industries (Máté, 2014), in the role of the technology transfer and diffusion (Máté et al., 2017; Postelnicu & Dabija, 2015).

Even though it is widely considered one of the most successful approaches to capturing global market share, particularly for emerging economies, adopting the most recent technological tools appears relatively slow among firms. This is although it is one of the most successful approaches. According to Nelson (2003), the consideration of emerging technologies has become an established norm in almost all sectors of the modern economy.

Nemoto et al. (2010) demonstrated that incorporating new technologies into a company is a prerequisite, and as a result, companies must consider the practicality and efficiency of technological progress to enhance their operational capabilities. In addition, these businesses have been seizing the opportunity presented by advances in technology to develop their procedures and modify them in line with innovations. This allows them to track the trends of the modern economy better and satisfy their requirements by applying technology as it becomes available. A growing number of businesses are opting to integrate with external providers of the tools and equipment they will need for their operations. This integrating method is becoming more popular. This is required to fulfill their internal demands and demand for new equipment and machinery, and this must be done.

2.2.2.1 Availability of the latest technologies and Economic Growth

Some scholars suggested that the positive effect of the latest technological adoptions is robust (Borensztein et al., 1995), and it has been shown that the transfer and dissemination of new technologies play a significant part in the rise of productivity (Postelnicu & Dabija, 2015). When new technologies are adopted and employed extensively throughout a population, only then will their potential to contribute to economic development be able to be fully realized. Diffusion is the result of a succession of individual choices to start using the new technology. These decisions are often the result of a comparison of the unknown advantages of the innovation with the unpredictable costs of adopting it.

Caselli & Coleman (2001) focused their research on the proliferation of computer usage in some OECD nations between 1970 and 1990. They discovered that the level of worker aptitude (as evaluated by educational level), the openness to manufacturing trade, and the total investment rate in the nation are among the major factors determining the degree of computer investment. As the authors point out, those findings show that the significance of trade openness is not based on the fact that computers account for a significant portion of manufacturing imports; instead, manufacturing imports of computers often account for just a tiny portion of the total. Kennickell & Kwast (1997) find evidence for the role of education, consumer skills, and learning in their research on the consumer adoption of electronic banking. This evidence is found at the household level in the United States. In 1995, seventy percent of all American homes utilized at least one kind of electronic banking, but only a tiny percentage of households used more current and sophisticated types of electronic banking, such as paying bills online. The most prevalent use of electronic banking was for making direct deposits, a technology that has been around for a while, is relatively well-established, and is extensively utilized globally; this serves as indirect confirmation of the presence of a learning effect. The pace of adoption is sped up due to the development and improvement of technology, and an increasing number of people are getting acquainted with it and feeling comfortable using it. All of these data demonstrate the significant impact that adjusting to changes in technology enhances overall productivity from a macroeconomic point of view.

2.2.3 FDI and technology transfer

There has been much debate and uncertainty around attitudes and policies about the liberalization of international capital flow in general and foreign direct investment (FDI) in particular (OECD, 2002). FDI, or foreign direct investment, is a type of investment that reflects the objective of establishing a lasting interest by an enterprise resident in one economy (the direct investor) in another enterprise (the direct investment enterprise) that is resident in an economy that is not the economy of the direct investor. This type of investment falls under the category of "foreign direct investment." The presence of a long-term connection between the direct investor and the direct investment enterprise, as well as a large degree of impact on the management of the firm, is necessary for the existence of a lasting interest in the enterprise. If the investor obtains at least 10 percent of the voting power of the direct investment firm, then the investor is considered to have an enduring interest in the business. The influence of disparities in the size of economies in the reporting nations is removed by expressing the data as a percentage of GDP. Foreign direct investment (FDI) includes the following: - Equity capital includes not just equity in branches but also all shares in subsidiaries and affiliates. - The direct investor's share of profits not dispersed as dividends by subsidiaries or associates and earnings of branches not remitted to the direct investor are included in reinvested earnings.

These earnings are reported under Investment income. - Debt instruments are the primary criterion for classifying direct investment in the direction of the investment:

1) Resident direct investment overseas (Outward direct investment)

2) Investments made by non-residents in the economy are being reported (Inward direct investment).

Inward direct investment is made by a non-resident direct investor in a direct investment firm located in the economy being reported on; the direction of the influence exerted by the direct investor is inward for the economy being reported on. Beginning in October 2014, definitions are to be based on the Sixth Balance of Payments Manual published by the IMF (BPM6). (OECD, 2019)

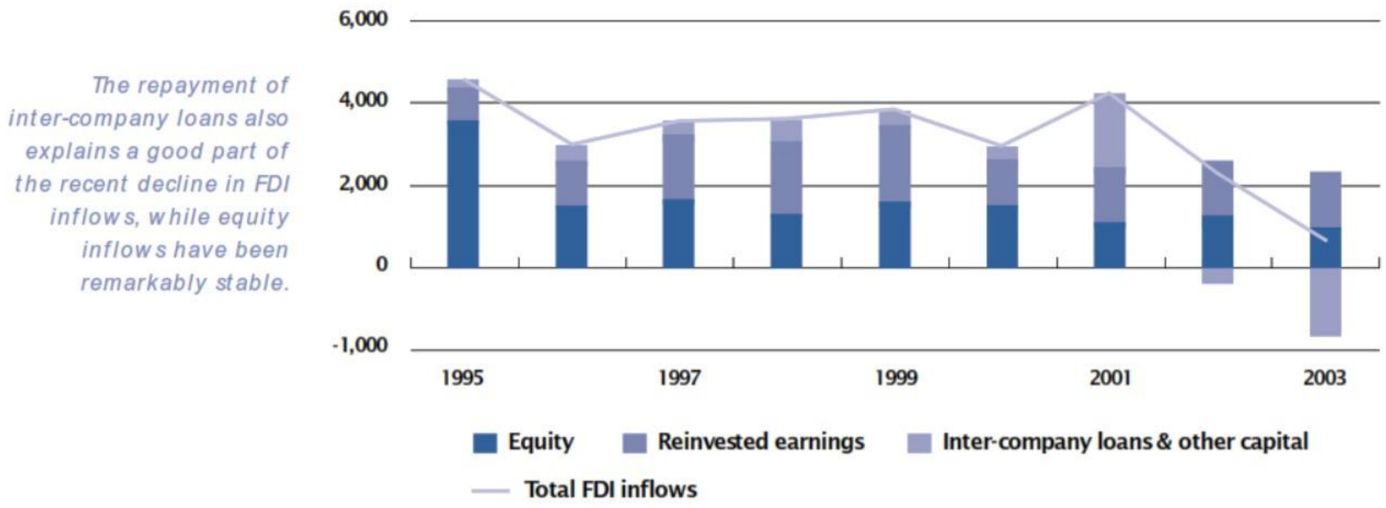
2.2.3.1 Inter-company loans as an FDI indicator

According to Sass (2004), inter-company loans count as one of the components of foreign direct investment (FDI), and they are a more significant source of finance for expanding capacity and making further investments in a host nation that already has a significant amount of FDI. However, evidence from throughout the globe suggests that inter-company loans can be very unpredictable and that a relatively small number of significant transactions might obscure trends underlying foreign direct investment (FDI). To demonstrate this point, using the example of Hungary, an inter-company loan of more than one billion euros was made in 2001, but this loan was returned over the following years, leading to huge yearly changes in the amount of foreign direct investment recorded.

This loan was not used to finance the formation of capital. It was given to the affiliate by the parent company of the German firm that it was affiliated with, and the affiliate utilized the loan to buy out its US partner in the shared venture.

In a broader sense, parent corporations would also employ loans amongst their subsidiaries as another method to extract funds during a recession. The following chart illustrates how fluctuating inter-company loans affect foreign direct investment in Hungary: it is evident that the significant withdrawals of inter-company loans in 2002-2003 go a long way toward explaining the steep reduction in FDI. The picture also illustrates that inter-company loans have a negative correlation with FDI. The yearly inflows of equity investments and reinvested earnings have steadily decreased from roughly EUR 3.5 billion in 1999 to EUR 2.5 billion in 2002. This Figure indicates that the more stable components of FDI, such as equity investments and reinvested profits, have been on a downward path since 1999.

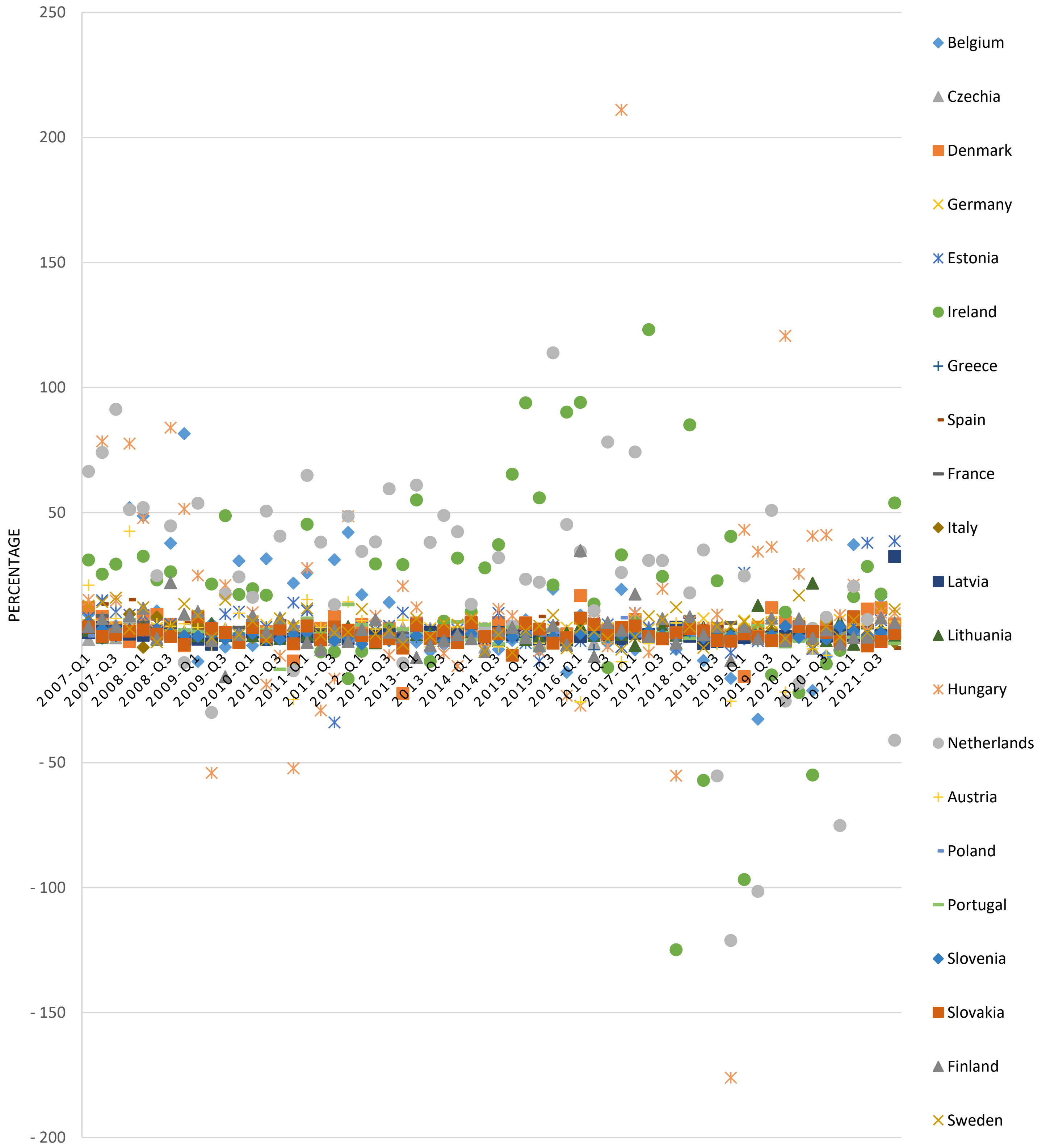
Figure 21
FDI inflows in Hungary, by component (millions of EUR), 1995-2003



Source: (Hungarian National Bank, 2003)

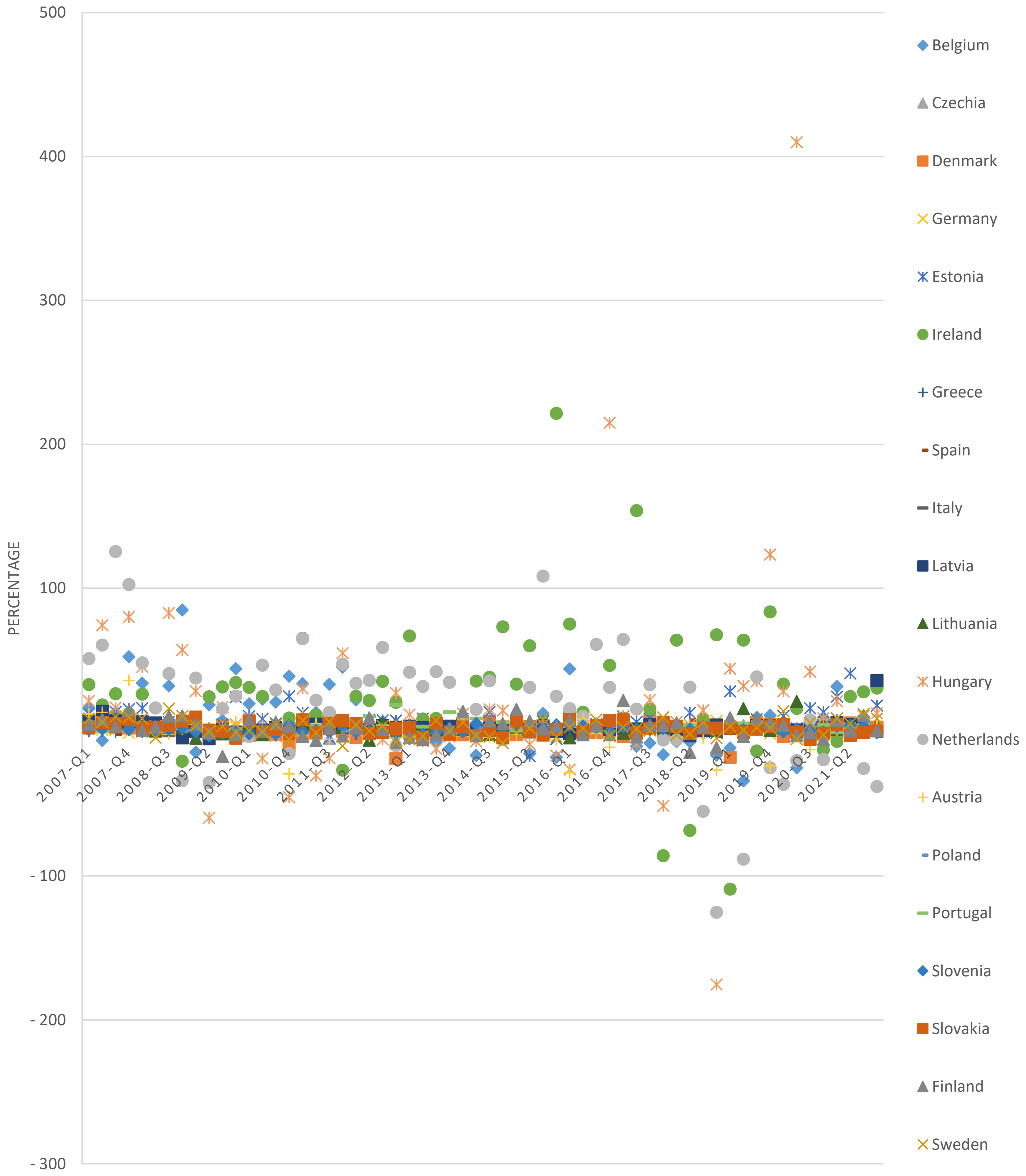
However, it is still unclear if this is merely a passing occurrence or whether it will become a consistent pattern in the future. In this setting, it is perhaps worth noting that contrary to a prevalent assertion, equity investments have not ended but continue to come into the nation, with an annual average of around 1.25 billion Euros since 1996. This would be relevant to the discussion because of the pervasive nature of the allegation. The process of privatization, which had been put on hold for the previous five years, was resumed in 2003 and expanded to include state-owned banks in addition to other businesses. To summarize, data deficiencies and transient impacts contribute to the explanation for the decrease in the amount of FDI flowing into Hungary. Having said that, it is nonetheless a fact that inflows associated with privatization have, for the most part, reached their natural conclusion and that the attractiveness of Hungary as a destination for foreign direct investment (FDI) has steadily decreased – in comparison to both the 1990s and other nations in the area. The introduction of formidable new rivals is mostly to blame for this development. Because other nations in the area saw the potential benefits of FDI, they followed Hungary's lead and established a functional regulatory environment, liberalization and privatization to foreigners, implementation of FDI incentives, and other similar policies. As a result, Hungary lost its first-mover position. However, unfavorable changes in economic policy lately have shared some of the blame for the deterioration in Hungary's attractiveness as a destination for foreign direct investment (FDI). Notable are the significant rises in real wages, the lack of coordination between fiscal and monetary policy, and the delayed implementation of changes to public expenditures.

Table 6
Resident Direct Investment Abroad (Outward direct investment) in OECD Countries,
Percentage of Gross Domestic Production (GDP)
2007,Q1-2021,Q4



** 0 means there is no data for this country this year.*
Source: Eurostat (online data code: TIPSBP53)

Table 7
Non-Resident Investment in the Reporting Economy (Inward direct investment) in OECD, Percentage of Gross Domestic Production (GDP)
2007,Q1-2021,Q4



** 0 means there is no data for this country this year.*
Source: Eurostat (online data code: TIPSBP51)

2.2.3.2 FDI, technology transfer, and Economic Growth

Some researchers found a positive relationship between foreign direct investment (FDI) and technology transfer variables and economic growth (Lensink & Morrissey, 2001; Blomström et al., 1992; Borensztein et al., 1995; Campos & Kinoshita, 2002).

Osano & Koine (2015) conducted a case study of the energy industry in Kenya to illustrate that foreign direct investment (FDI) and the transfer of technology have a significant association with economic development. Most positive effects of foreign direct investment are attributable to the transfer of intangible assets, such as technology, knowledge, and other forms of intellectual property, leading to higher production levels and more effective use of resources (Khawar, 2005).

On the other hand, some scholars, such as Borensztein et al. (1995), demonstrated a statistically significant inverse connection between the linear term of foreign direct investment and economic growth.

Most of the research suggests that the link should be positive, with foreign direct investment (FDI) and technology transfer leading to increased levels of productivity. In a particular study, Zhang (2001) discovered that foreign direct investment (FDI) and economic growth had a positive correlation. Zhang investigated the relationship between foreign direct investment (FDI) and economic development by using data from 11 countries located in East Asia and Latin America. Other researchers, such as Bengoa & Sanchez-Robles (2003), investigate the relationship between economic freedom, foreign direct investment, and economic development using panel data analysis for a sample of 18 Latin American nations between 1970 and 1999. They concluded that the level of economic freedom in the host nation is a factor that positively affects the amount of foreign direct investment.

In addition, Bayarçelik & Taşel (2012) investigated not only FDI but also the connection between the number of researchers working in R&D departments, the amount of money spent on R&D, patents as measures of innovation, and Gross Domestic Product (GDP) as an indication of economic development. They investigated these links for chemical companies that were listed on the Istanbul Stock Exchange (ISE) between the years 1998 and 2010 by using panel regression. According to the findings, there is a significant relationship between the number of workers working in R&D and the GDP. However, the association between R&D spending and GDP is only moderately strong.

2.3 Institutions

The word "institution" conjures up images of a location where a group of individuals congregates to engage in some kind of educational or R&D (research and development) endeavor. In general, institutions relate to laws developed by humans and regulate the behavior of humans (De Cremer & Van Vugt, 1999). The old neo-classical theory of economics has a narrower understanding of what is meant by the term "institutions matter," whereas the new institutional economics has a more expansive view (North, 1986).

A collection of institutional ideas that take into account economic, political, and sociological aspects is referred to as neo-institutionalism. In recent years, some institutional economists, such as the Nobel-prize winner North (1993), have asserted that "institutions matter," which is highly significant in comprehending the general history of economic expansion (Dugger, 1995). The study of modern institutional economics ought to focus on the man in his natural state, as he functions within the boundaries set by actual institutions. Economics, as it should be practiced, is captured by modern institutional economics (Coase, 1984). According to this interpretation, institutions may always be seen engaging in connections with others.

The frameworks of more precise norms that regulate human behavior are designed based on more general and shared understandings formed by individuals and communities through time, often known as culture. We refer to these entities as institutions. Various personalities and organizations build distinct institutions. Institutions may be found in various contexts, including but not limited to families, corporations, government entities, and religions (Keizer, 2008). Institutions are the laws, conventions, and regulations that underpin economic activity. Institutions are seen as essential to properly comprehend economies because they help organize various incentives and restrictions, influencing how an economy shifts and develops over time (North, 1993).

Within the field of sociology, the "center of analysis" is referred to as the "institution" notion. When it comes to the explanation of economic performance, however, some economists concur that "institutions matter."

The foundation of contemporary institutional economics is built on two premises:

1) The theoretical framework should be able to integrate neoclassical theory with an analysis of the way institutions modify the choice set available to human beings;

2) The framework should build upon the primary determinants of institutions so that we can not only define the choice set that is available to people at any given time but also analyze how institutions change and, as a result, alter the available choice set over time (North, 1986).

Contemporary institutional economics has an investigative political and economic approach that proposes a relationship between idea and observation. Both of these fields are interdisciplinary. The individual contracts that are created based on legal cases, property rights, and political decision rules are the fundamental building blocks, which means that they are the complex observations that are available to be investigated. The observations are used by theory to provide knowledge of institutional processes and an analysis of the transformation of institutions.

Within this institutional framework, people and organizations compete with one another to seize the benefits that result from the specialization of labor and the division of responsibilities. Contracts stipulating conditions of trade may be formed between individuals, either willingly or involuntarily, via the use of force or threat of force. An organization is formed when many separate contracts are brought together under the terms of a single overarching contract (Alchian & Demsetz, 1972). A theory of the political process, a theory of the state, and how the institutional structure of the state and its individuals specify and enforce property rights should be a part of the new institutional economics. In addition to being a theory of property rights and their evolution, the new institutional economics should also be a theory of these things. Institutions serve the purpose of structuring interactions between actors by determining the availability and nature of options, as well as providing information, with the goals of lowering the degree of uncertainty and influencing the behavior of actors to produce more desirable outcomes for society (P. A. Hall & Taylor, 1996).

2.3.1 Institutions and Economic Growth

Productivity is the most important factor in the development of new institutions. An increase in productivity brought a greater level of specialization and division of labor. This technique is illustrative of the conventional balancing structure of neoclassical economics. In that structure, there is no cost of transacting, and as a result, there are no institutions because the cooperation of individuals comprises fixed costs of transacting. This method differs from that structure. On the other hand, transaction costs may account for a broad range of GDP as productivity when viewed from a macroeconomic viewpoint (North, 1986). In the first chapter of Structure and Change in Economic History, North Douglass makes a distinction between what he calls a "contract theory" of the state and what he calls a "predatory theory" of the state (1981, pp.20-27). The first hypothesis proposes that the state and the affiliated institutions are responsible for providing the legal framework that makes it possible for private contracts to expedite economic transactions (also known as "reducing transaction costs"). The second theory proposes that the state is nothing more than a mechanism via which resources may be moved from one group to another. Throughout his book, North develops a story that combines the two theories and argues that good institutions will simultaneously support private contracts and provide checks against expropriation by the government or other politically powerful groups. This is central to North's argument that good institutions will simultaneously support private contracts and provide checks against expropriation. Also, the scholarly literature has asserted that the presence of institutions leads to increased productivity. During the past few decades, more attention has been devoted to the economic literature on the concept of new institutional economic theories. These theories, which deal with levels of institutions and institutional stickiness, highlight the significance of the environment in which markets function. One of the most prevalent arguments made by these individuals is that the "formal" and "stickiest" external institutions in a society are where a society's "informal" fundamental institutions, such as its norms and culture, are completely embodied. In this sense, formal institutions are only advantageous when certain informal institutions are also present (Williamson, 2009). Meanwhile, more powerful institutions may improve the welfare and productivity of the whole world (Diwan & Rodrik, 1989) and (Taylor, 1994).

However, researchers are often intrigued by the investigation of how technological advancements and established institutions influence the functioning of economies. However, much debate is going on right now regarding whether or not technology and institutions are important for productivity and whether or not technology and institutions increase the worldwide competitiveness of companies. In light of the information presented above, this study aimed to explore the elements that impact productivity growth from a technological and institutional perspective.

2.3.2 Property Rights

The theory of property rights does not emphasize who "owns" something; instead, it examines the formal and informal provisions that determine who has a right to enjoy benefit streams that emerge from the use of assets and who have no such rights. These provisions can be formal contracts or unwritten norms.

Some scholars have researched a variety of property rights and made attempts to define them within a variety of contexts (Alchian, 1965; Fisher Matthew, 2007; Penner & Smith, 2013; Sheehan & Small, 2002).

The regulations may have been derived from user group norms, customary law, state law, or any number of other frameworks. Statutory law enforcement is often the duty of the state, which indicates that formal laws are the foundation upon which rights are founded.

Property rights that are based on other sorts of norms may be enforced by customary authority or by a user group, which either oversees the distribution of rights or has members of that organization "define or enforce rights among themselves."

The two components that make up property rights are the rule and the method by which it is enforced. The rule describes how a certain governance system legally acknowledges and protects the property. Property rights, in the context of natural resources, relate to the connection between people, organizations, and collectives that own appropriate rights to access, use, control, and exclude others from the resource in question. Formal and informal property rights systems identify who has valid claims to the benefits of using certain resources. Property rights systems may be either public or private. If any legal framework does not support these claims, they do not represent legitimate property rights (Schlager & Ostrom, 1992). It is vital to explain who has property rights and under what circumstances to have a practical comprehension of property rights. The three most frequent kinds are communal, collective, and private forms of property rights (Ostrom, 1990). The rights of ownership over assets that several persons hold at the same time are known as communal property rights. Even though this is not always followed stringently, one definition of this sort of ownership is open access, meaning there is no exclusive control over the resources. When constraints exist on who may enter a resource or who can leave a resource, collective property rights are in effect. These restrictions can go either way. When one person or group has exclusive authority over a set of resources, this is known as "private ownership." It is possible for private property rights to exist in the absence of a formalized structure for either governance or enforcement.

According to Carruthers & Ariovich (2004), property rights have significant implications for both the general prosperity of the country and the well-being of its citizens. Changing a nation's approach to property rights may move it to a whole new place in that nation's social hierarchy. Property rights, like any other right, cannot be enforced unless they are first recognized and sanctioned by the whole community. Because of the varying environmental and socioeconomic conditions in each country, various communities are willing to adopt a variety of diverse systems. Every culture responds to new developments in its environment based on the lessons it has learned in the past. The many kinds of laws in different nations result from different historical experiences, even though regulations in each country have certain fundamental elements in common.

Nowadays, the formation of certain laws guiding the use of resources that are in short supply in the environment in which people live has evolved from being an option to an absolute need. Property rights are the many arrangements that are put into place to allow persons to make efficient use of the resources that are available to them. The rights at issue set the criteria that must be met to get certain resources for a person, group, or organization. The use of rights associated with personal property, in contrast to those associated with other types of property, is subject to various penalty mechanisms (Alchian & Demsetz, 1972).

2.3.2.1 Intellectual Property Rights (IPR)

According to Haydaroğlu (2015), property rights may be divided into physical and intellectual property rights. Physical Property Rights (often known as PPR) contain three sub-variables that play a significant role in preserving private property rights. These include safeguarding rights to one's physical property, registering one's property, and incurring financial obligations.

Intellectual property rights (IPR) such as patents, policies, and actions, as well as trademarks and copyrights, must be protected. The four sub-branches that fall under this category are the protection of intellectual property rights, the protection of patents, the prevention of copyright theft, and the protection of trademarks. The rating system used by the IPRI (International Property Right Index) ranges from zero to ten. While a score of ten shows the highest degree of protection for property rights, a score of zero indicates no safety for property rights in the nation being considered. In addition to the overall rating, a score between zero and ten is assigned to both the primary component and each variable.

The law, the economy, the state, and culture all converge at the point where property rights are concerned. Property rights are a major topic of discussion among scholars who study economies in transition. For instance, intellectual property rights (IPR) are of concern to leading- industries such as biotechnology and computer technology. The property also serves as the basis for numerous types of inequality. Despite this, modern sociology has spoken considerably less about property than its relevance merits and has generally ceded the matter to economics and law.

The research conducted by Carruthers & Ariovich (2004) investigated the connection between sociology and property rights. According to what was said, property rights cover law, economics, state, politics, science, and culture; as a result, they have a great deal of significance to sociology. Variations in property rights along the dimensions outlined above should be the primary focus of study in the future, with a particular emphasis on recording empirical trends and working toward answers. Some questions that immediately spring to mind include: how exactly do new subjects and new objects of property come into existence? Is there a correlation between the distribution of new assets and the disparities that existed in the past, and if so, what are the consequences for the perpetuation of inequality? Will there be a single property rights system that predominates as a result of global integration? What kind of a balance exists between formal and informal property rights, and do the two types of rights compete with one another, or do they complement one another? In what ways does the politics of property manifest itself at times of institutional transformation? How do social or cultural interests interact with formal property rights in things? What is the nature of this interaction? How important are openness and consistency in the administration of property rights? For these rights to be considered legitimate claims, they must be ratified by some kind of group. As a result, property rights need a link between the person holding the right, other people, and a governance system to support the claim. As a result, it will be vital to understand the significant function of property rights in a community.

IPRs preserve ownership rights and give exclusive rights or licenses to right holders to use IPRs without facing any unlawful challenges from other parties. In addition, IPRs allow the right holders the ability to use IPRs without having to pay royalties. Patent law is often regarded as one of the most significant forms of intellectual property protection because of the protection and encouragement it offers to innovators. (Fang et al., 2016) studied the relationship between IRPs and innovation in China. They found how the protection of intellectual property rights (IPR) influenced innovation in China in the years leading up to the privatization of state-owned companies (SOEs). After SOEs are privatized, there is a rise in innovation, and this growth is greater in places with robust intellectual property rights protection. Their findings provide credence to the theoretical claims that intellectual property rights protection encourages firms to develop and that private sector companies are more responsive to IPR protection than state-owned enterprises.

Patents are awarded for ideas that are both novel and helpful, and they come in the form of a patent. A patent grants the owner the right to prevent others from creating, using, or selling an invention without first obtaining permission from the owner of the patent.

An inventor who has applied to a product, design, or procedure that has not yet been granted a patent is given a patent receipt as a token of appreciation for their efforts. Patent receipts are regarded as exclusive gifts, and they provide the owner the right to prevent others from financially exploiting other people's innovations for the duration of the patent on those inventions, provided that those other people first secure patents for themselves (Potts, 1944).

2.3.2.2 Property rights measurement

Due to difficulties in acquiring quantitative indicators from the data about property rights, measuring property rights or determining it as a specific value is a major problem. Nevertheless, by looking at how things work in the economic and social spheres, one may figure out how structures are shown by property rights. Survey data are the primary approach to determining the scope of property rights in the modern era. International organizations and private researchers collaborate to undertake cross-national comparative analyses and develop survey indexes as a consequence of these efforts. These analyses and indicators are then utilized extensively in empirical research. These studies are generated by private firms, international organizations, business leaders, and people face-to-face or based on data gathered from interviews done over the telephone. A reference is also made to the "International Property Rights Index" (IPRI). This index was first released in 2007 and was made using the intellectual property rights that belong to the alliance's efforts (LEVY CARCIENTE, 2015). In the index, various factors are organized under three primary headings: Legal and Political Environment, Economic Environment, and Social Environment (LP). The robustness of a country's legal and political systems is regarded as the country's perspective on the significance and preservation of its intellectual property rights. This title addresses not only the autonomy of the judicial system but also the degree to which the public has faith in the judicial system, the degree of political stability, and the varying degrees to which public officials accept bribes.

In the next part of this section, the terms "Trade Market Index" and "Community Design Index" will be used to refer to two more categories of property rights.

2.3.2.3 Property rights as Trade Mark

A trademark is a symbol (a word, a logo, a phrase) that allows consumers to differentiate the products or services of one party from those of another. This distinction is made possible by the legal definition of a trademark (Millot, 2009). One of the most valuable things that companies own is their trademark portfolio. It is primarily because of them that people are familiar with the businesses, and it is also through them that the firms' reputations may be established. They allow customers to distinguish between competing products and services and, perhaps, establish brand loyalty to a single favored trademark. Because of this strong customer connection allows the company to charge greater prices while maintaining better profit margins. Indeed, customer loyalty to a particular brand causes individuals to be willing to spend a greater amount for a single item, according to Davis (2002). According to (ELLIOTT and PERCY 2006) a powerful brand name is one of the most important factors contributing to a firm's financial success. The sign's uniqueness, which cannot be confused with any other registered trademark, is the only need to register a new mark as a trademark. To avoid misunderstanding among customers, the trademark should be able to identify a certain category of goods single-handedly. In contrast to patents, trademark registration does not require that the product in question be original. As a consequence of this, the connection between trademarks and innovation is not an easy one to make from a legal standpoint.

In a business, however, trademarks are very likely to be connected to the inventive activity of companies on a variety of different levels. To begin with, trademarks are important components in the process of bringing new items to the market. When companies introduce innovations to the market, they often couple such developments with the introduction of new brands to influence how customers see the new offerings. Companies will promote their products using the brand as the foundation for their marketing efforts. The trademark, therefore, has a strong possibility of becoming a reference on the market for the product or possibly becoming the reference on its own. Indeed, customers who begin purchasing one innovative product from a single brand are more likely to continue purchasing products from that brand in the future. When this occurs, it becomes more difficult for potential rivals to join the market. Consequently, trademarks may serve as a tool to usurp the advantages of the invention. Since then, several product advancements made by companies are connected to a trademark (for example, the "Kleenex," which was created in 1924 by the company Kleenex (Lindsay & Hopkins, 2010); the "Walkman" which was first introduced by Sony in 1979 (Guglielmo et al., 2010); the "i-phone," which was introduced by Apple in 2007 (Laugesen & Yuan, 2010)). The use of trademark data as an indication offers a variety of benefits, both theoretical and practical. They have been documented on a consistent and methodical basis for many decades in a great number of nations, at least in the countries with the most advanced economies. They have a high number of trademark applications, which means it should be possible to achieve statistically relevant results; the data are accessible through electronic databases; they are disaggregated by classes of products, which should enable sectoral analyses (West & Mace, 2007).

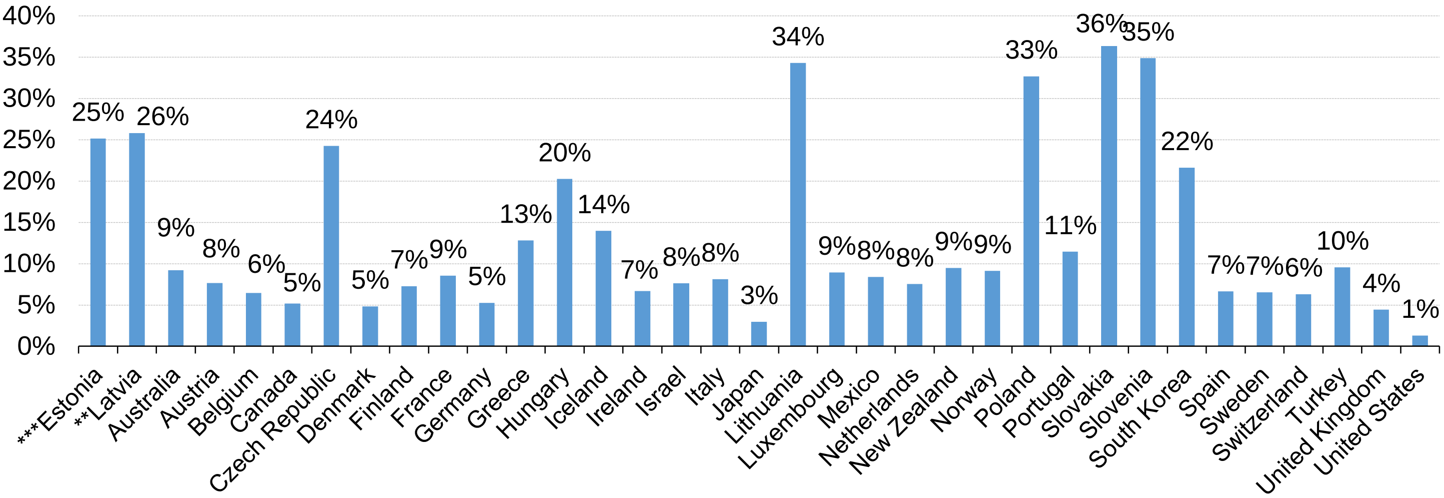
Now, they are present all over the world, making it theoretically possible to make international comparisons. In addition, they present all of the practical characteristics required to constitute an excellent statistical indicator. These characteristics are as follows: there are many trademark applications; therefore, it should be possible to (Schmoch, 2003).

Table 8
Trade Mark Applications of the OECD countries,
1996-2015

Country	Total number 2015	the average number per the year 1996-2015	The average number per billion GDP 1996-2015	The average number per million population 1996-2015
Australia	1,402	635.5	0.9	29.9
Austria	2,966	1,642.1	5.9	197.5
Belgium	2,239	1,229.5	3.7	114.4
Canada	1,215	764.7	0.8	21.7
Czech Republic	992	376.6	2.6	36.1
Denmark	1,742	1,014.3	4.7	185.2
Estonia	355	115.2	6.9	86.8
Finland	1,372	682.2	4.0	128.4
France	7,899	5,025.4	2.7	78.9
Germany	20,400	12,858.3	5.2	157.6
Greece	771	339.6	1.8	31.0
Hungary	565	208.6	2.2	20.9
Iceland	72	47.2	4.0	149.6
Ireland	1,067	666.6	4.4	156.4
Israel	447	252.0	1.8	35.4
Italy	9,930	5,870.6	3.9	100.1
Japan	2,597	1,753.8	0.5	13.8
Latvia	157	70.1	3.3	33.7
Lithuania	271	97.4	3.1	31.9
Luxembourg	1,233	652.8	18.7	1,320.8
Mexico	310	174.9	0.3	1.6
Netherlands	4,532	2,563.3	4.4	155.8
New Zealand	297	149.1	1.6	35.3
Norway	426	217.5	0.8	45.3
Poland	3,663	1,126.1	3.2	29.6
Portugal	1,331	725.7	4.5	69.3
Slovakia	363	138.3	2.1	25.6
Slovenia	294	111.3	3.1	54.5
South Korea	2,058	458.5	0.6	9.3
Spain	9,405	5,733.7	6.3	128.9
Sweden	2,888	1,544.2	4.5	166.9
Switzerland	3,964	2,362.5	5.9	307.5
Turkey	772	218.7	0.5	3.0
United Kingdom	12,526	7,723.6	4.1	125.7
United States	16,894	12,322.2	1.2	41.4
World	130,428	75,149.7	:	:

Source: Eurostat (online data code: ipr_ta_tot, ipr_ta_gdp, ipr_ta_pop)

Figure 22
Compound Annual Growth Rate (CAGR) of the OECD trademark applications, 1996-2015



*** LV beginning year=1999, *** EE beginning year=1998*

Source: Eurostat (online data code: ipr_ta_tot)

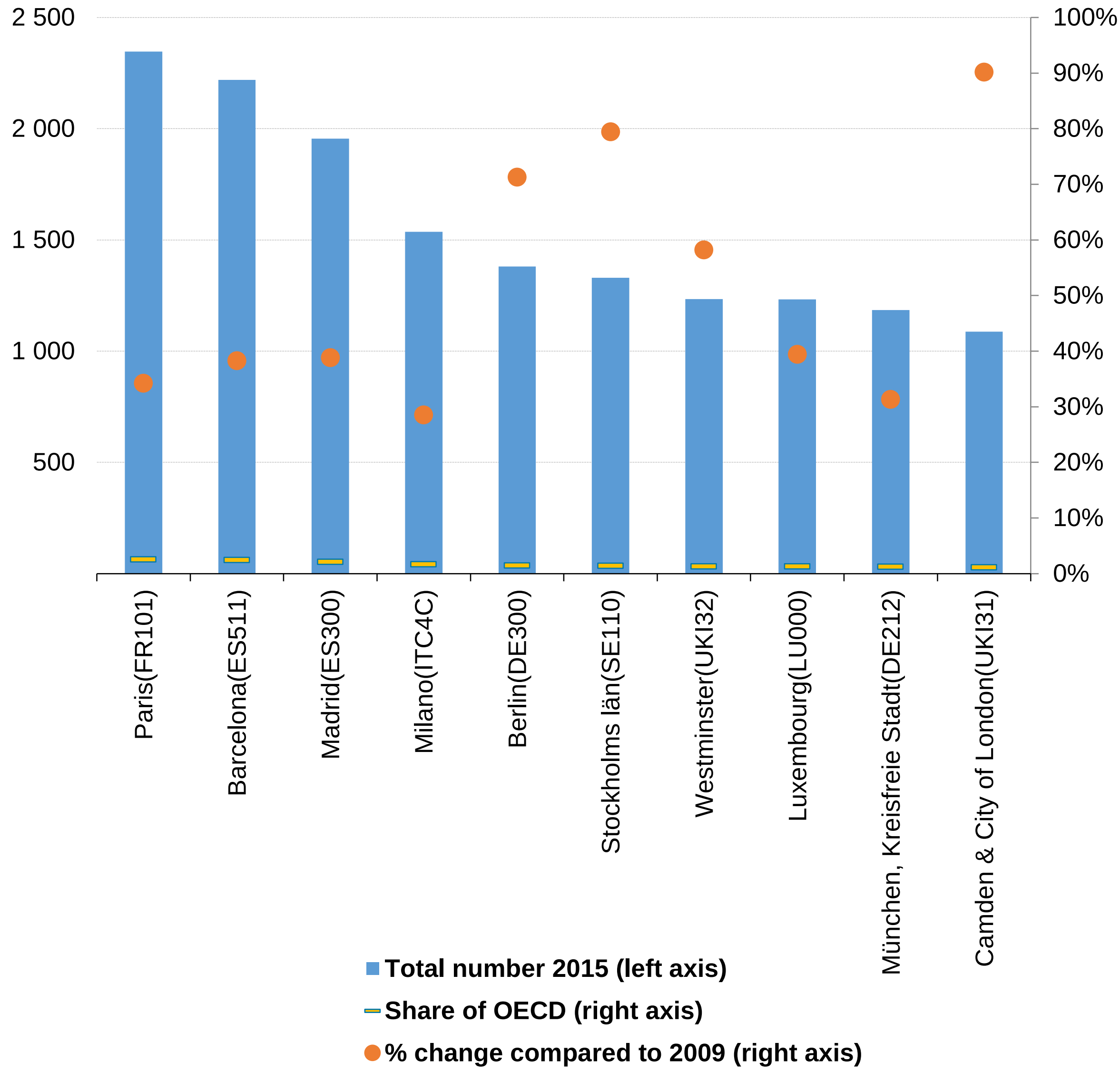
Table 9
Co-ownership of OECD and Non-OECD trademark applications
1996-2015

No.	Year	Single ownership	OECD co-ownership	Non-OECD co-ownership	OECD and non-OECD co-ownership
1	1996	98.3%	1.4%	0.2%	0.1%
2	1997	96.9%	2.3%	0.6%	0.2%
3	1998	97.0%	2.4%	0.3%	0.3%
4	1999	97.3%	2.2%	0.3%	0.2%
5	2000	97.6%	2.0%	0.3%	0.1%
6	2001	97.6%	2.0%	0.2%	0.1%
7	2002	97.3%	2.1%	0.4%	0.1%
8	2003	97.3%	2.2%	0.4%	0.2%
9	2004	97.1%	2.5%	0.3%	0.2%
10	2005	97.3%	2.1%	0.4%	0.2%
11	2006	96.9%	2.6%	0.3%	0.2%
12	2007	96.9%	2.6%	0.2%	0.2%
13	2008	97.1%	2.6%	0.2%	0.1%
14	2009	96.8%	2.7%	0.3%	0.2%
15	2010	96.4%	3.0%	0.2%	0.3%
16	2011	96.7%	2.8%	0.3%	0.2%
17	2012	96.6%	3.0%	0.3%	0.1%
18	2013	96.4%	3.1%	0.3%	0.2%
19	2014	95.5%	3.4%	0.3%	0.7%
20	2015	95.4%	3.5%	0.3%	0.8%

**The calculation of co-ownership shares is based on World totals at the annual level*
Source: Eurostat (online data code: ipr_tc_sng, ipr_tc_eu, ipr_tc_neu, ipr_tc_euneu)

Table 10
Top 10 regions for the OECD trademarks, by NUTS level 3 region, 2015

NUTS	Total number 2015 (left axis)	% change compared to 2009 (right axis)	Share of OECD (right axis)
Paris(FR101)	2347	34.3%	2.6%
Barcelona(ES511)	2220	38.3%	2.5%
Madrid(ES300)	1955	38.9%	2.2%
Milano(ITC4C)	1536	28.5%	1.7%
Berlin(DE300)	1381	71.3%	1.5%
Stockholms län(SE110)	1330	79.5%	1.5%
Westminster(UKI32)	1234	58.2%	1.4%
Luxembourg(LU000)	1233	39.5%	1.4%
München, Kreisfreie Stadt(DE212)	1185	31.4%	1.3%
Camden & City of London(UKI31)	1088	90.2%	1.2%



Source: Eurostat (online data code: ipr_ta_reg)

2.3.2.4 Property Rights as Community Design

A unified industrial design right that encompasses the whole European Union is called a "Community design." It can be submitted in either an unregistered or registered version. The Community design that had not been registered entered into force on March 6, 2002, and the Community design that had been registered became accessible on April 1, 2003 (EC, 2013; IIC, 2014). The OECD member states are all covered by the protection offered by a Community design. Community designs must be creative and reflect each community's unique personality (Rein, 1997).

According to Massa & Strowel (2003) if a designer wants to secure the design of their most recent product,1 a cornucopia, which has been further enhanced by the new pact with Europe, provides them a broad variety of options from which to choose, including at least seven potential protections (European Community protections): (1) Community unregistered design; (2) Community registered design; (3) Community trade mark; —national or regional (in the Benelux) protections: (4) national or Benelux design; (5) national or Benelux trademark; —national protections: (1) Community unregistered design; (2) Community registered design; (3) Community trade mark; —national protections: (1) Community unregistered design; (2) Community registered design; (3) Community trade mark. (6) The violation of copyright, and maybe (7) engaging in unfair business practices.

The New Deal for Europe is composed of the following four main lines:

—The Directive2 comes close to (or "harmonizes") the majority of the substantive requirements of national (or Benelux) design regulations, and it was to be implemented by the Member States no later than October 28, 2001.3 —The Regulation 4 establishes a unified Community unregistered design right (abbreviated as 'UCD'); this provision has been in place ever since the Regulation came into force on March 6, 2002. —The Regulation also establishes: —The Regulation also establishes a unified Community registered design right (abbreviated as "RCD"), for which the OHIM5 in Alicante, Spain, is to accept applications. Its impact was subject to implementing procedures, which came into effect over the Christmas holiday in 2002.6 —First and foremost, the Directive and the Regulation both permit design right to overlap (or "cumulate") with national copyright 7 and other national forms of protection 8; but, in reality, national copyright protection will continue to be essential.

The elements of Regulation 6/2002 that pertain to the substance of the matter are modeled after the Design Directive 98/71, while the provisions that pertain to the form of the matter are modeled after the Community Trade Mark Regulation 40/94.

ITMA (2006) discussed that an application for the registration of a Community design could be submitted to OHIM, “Office for Harmonisation in the Internal Market” (Trade Marks & Designs), the Benelux, or a national office; however, if it is submitted to a national office, it must then be submitted to OHIM. It is possible to integrate numerous designs into a single multiple application provided that, except in situations involving ornamentation, the items to which the designs are applied or in which they are included are all of the same class. The application is reviewed for compliance with the formal standards, but there is no evaluation of the applicant's uniqueness or originality. In the processes for post-registration invalidity, this issue is addressed.

The duration of the registration for community designs is five years. The duration of the registration may be increased (renewed) by increments of five years, up to a maximum of twenty-five in total. This later application can be given the same date as their first application if the owner applies for a design registration for the same design within six months of the first application in one of the countries that are a party to the Paris Convention for the Protection of Industrial Property or are members of the World Trade Organization. Putting forth a claim for priority or the right to go first is what this phrase means.

An unregistered Community design right is not formed by registration; it is established automatically when the owner makes a design accessible to the public. Registration is required to establish a registered community design right. When a design is made accessible to the general public for the first time, the date on which the design's protection as an unregistered Community design begins to run. This protection lasts for three years.

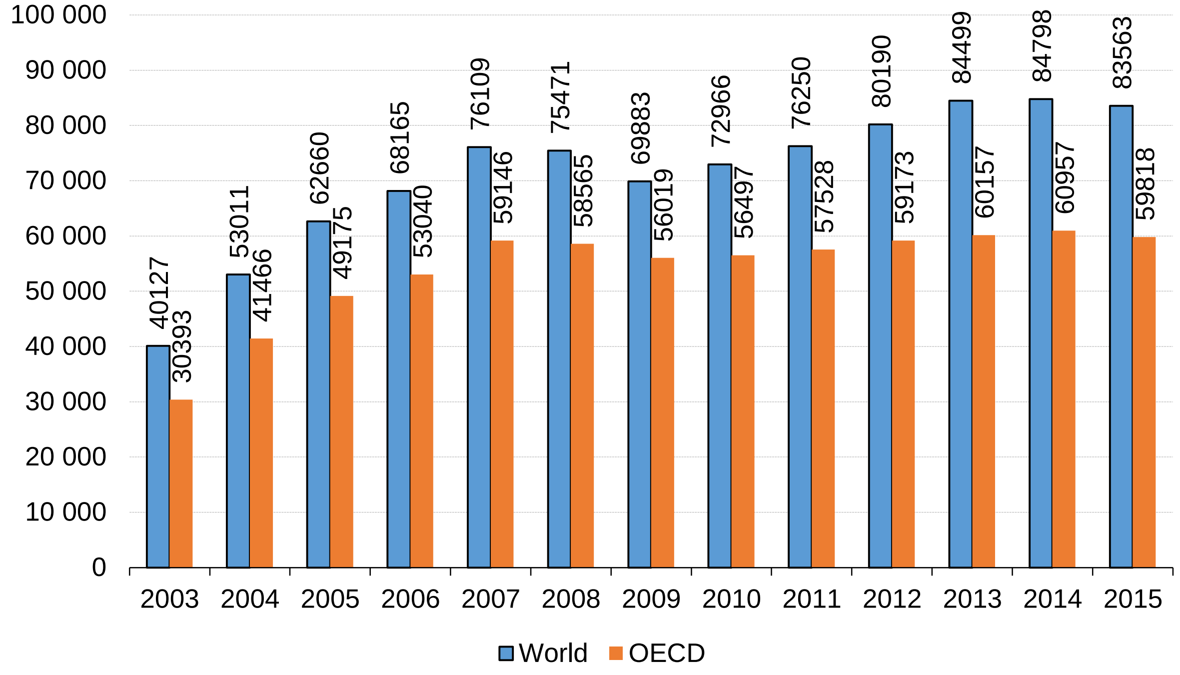
The owner of an unregistered Community design has the right to restrict other parties from using this design without their authorization, although this right may only be used if the design is being used to counterfeit goods. When someone copies a design protected by a Community design, they are violating the proprietor's exclusive right to use the design, granted by a Community design that has not been registered. A registered Community design is a monopoly right that confers upon the owner the exclusive right to use the design regardless of whether or not the design has been copied. This right can be used even if the design has been copied. The right to utilize a space first The Regulation establishes a right of previous use that is vested in a person who can prove that he has, in good faith, initiated usage within the Community or that he has made serious and effective preparations for that goal. This right of prior use can only be exercised by the person who can establish that they have done so. The right of previous use permits the person involved to exploit the right, but it does not extend to granting a license or transferring the right unless it is done so as part of a company.

Table 11
Community Designs (CD) filed in OECD countries,
2003-2015

Country	Total number 2015	The average number per year 2003-2015	The average number per billion GDP 2003-2015	Average number per million population 2003-2015
Australia	309	336.9	0.4	15.4
Austria	2,078	1,907.7	6.5	228.4
Belgium	969	1,113.6	3.2	103.2
Canada	388	394.5	0.3	10.5
Czech Republic	774	549.2	3.7	52.7
Denmark	1,603	1,323.1	5.6	240.0
Estonia	105	58.5	3.4	44.1
Finland	861	683.5	3.6	127.8
France	5,643	5,798.7	2.9	90.1
Germany	16,951	16,663.9	6.5	204.3
Greece	219	96.6	0.5	8.8
Hungary	142	135.7	1.4	13.6
Iceland	1	8.3	0.7	26.6
Ireland	285	251.7	1.4	57.4
Israel	306	171.0	1.0	22.6
Italy	9,798	9,397.5	6.0	159.5
Japan	2,225	2,323.9	0.6	18.2
Latvia	85	55.3	2.8	26.2
Lithuania	68	37.7	1.2	12.3
Luxembourg	707	352.0	8.4	682.9
Mexico	40	13.7	0.0	0.1
Netherlands	1,912	2,128.9	3.5	128.8
New Zealand	91	79.5	0.7	18.5
Norway	79	155.7	0.6	32.7
Poland	4,250	2,091.2	5.7	54.9
Portugal	827	762.8	4.5	72.6
Slovakia	126	118.8	1.9	22.0
Slovenia	136	103.4	2.9	50.7
South Korea	1,077	1,032.3	1.2	20.8
Spain	3,269	3,729.4	3.7	82.6
Sweden	1,517	1,391.9	3.8	149.4
Switzerland	2,380	2,028.9	4.9	261.8
Turkey	237	248.2	0.5	3.4
United Kingdom	6,040	4,780.7	2.4	76.8
United States	8,014	6,089.1	0.5	19.8
World	83,563	71,360.9	:	:

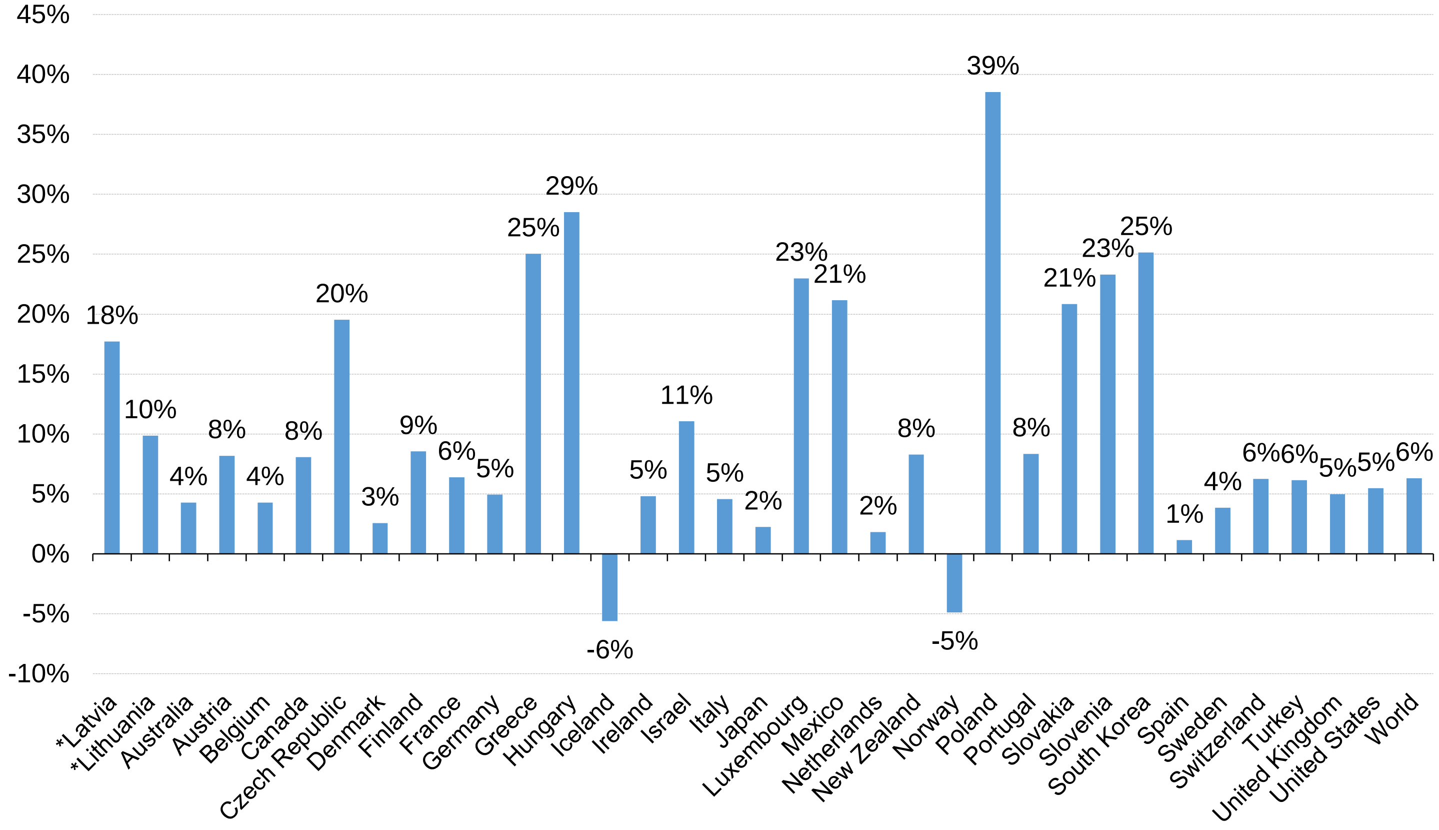
Source: Eurostat (online data code: ipr_dfa_tot, ipr_dfa_gdp, ipr_dfa_pop)

Figure 23
Community Designs (CD) field comparison between OECD and Total countries, 2003-2015



Source: Eurostat (online data code: ipr_dfa_tot)

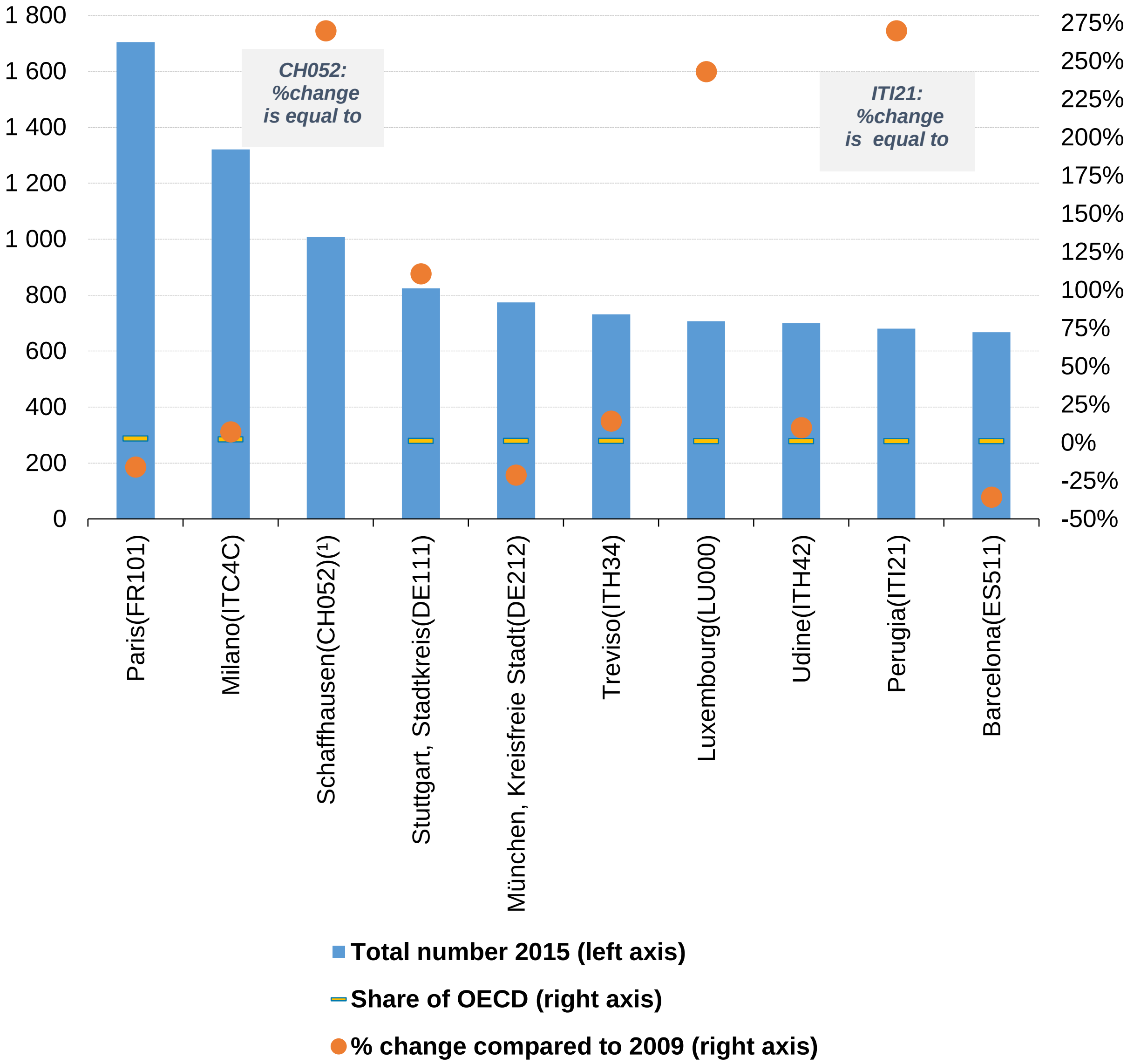
Figure 24
Compound Annual Growth Rate (CAGR) of Community Designs (CD) filed in OECD, 2003-2015



Source: Eurostat (online data code: ipr_dfa_tot)

Table 12
Top 10 regions for Community Designs (CD), by NUTS level 3 region, 2009-2015

No	NUTS	Total number 2015 (left axis)	% change compared to 2009 (right axis)	Share of OECD (right axis)
1	Paris(FR101)	1705	-13.2%	2.9%
2	Milano(ITC4C)	1321	7.3%	2.2%
3	Schaffhausen(CH052)(¹)	1008	3375.9%	
4	Stuttgart, Stadtkreis(DE111)	824	110.7%	1.4%
5	München, Kreisfreie Stadt(DE212)	774	-20.0%	1.3%
6	Treviso(ITH34)	732	14.4%	1.2%
7	Luxembourg(LU000)	707	233.5%	1.2%
8	Udine(ITH42)	701	9.9%	1.2%
9	Perugia(ITI21)	680	535.5%	1.1%
10	Barcelona(ES511)	668	-35.3%	1.1%



Source: Eurostat (online data code: ipr_dfa_reg)

2.3.2.5 Property Rights and Economic Growth

Property rights are often highlighted as the key example of how institutions may affect economic development in the empirical literature (Acemoglu et al., 2000; Acemoglu & Johnson, 2003). There are several ways in which property rights influence economic development. First and foremost, ensuring that property rights are protected will make it more attractive for households and individuals to make financial investments. In many cases, this will also improve their access to credit, which will assist them in making investments of this kind and serve as an assurance substitute if a shock occurs. Second, it has been known for a long time that in agriculture that is not mechanized, the operational distribution of land influences production. This implies that a very uneven distribution of land would result in a reduction in productivity. Secure and well-defined land rights are vital for household asset ownership, productive development, and the operation of markets, despite the fact that the capacity to make productive use of land will rely on policies in areas outside a land policy that may merit distinct attention.

According to the findings of Sattar & Mahmood (2011), intellectual property rights provide a favorable and considerable contribution to economic development all over the globe. In addition, after categorizing all of the countries in the sample into high-income countries, upper-middle-income countries, lower-middle-income countries, and low-income countries, they discovered that the impact was significantly greater in high-income countries than in middle and low-income countries. Furthermore, it concludes that the influence of intellectual property rights on economic development is more effective in upper-middle nations than in lower-middle-income countries, which is greater when compared with low-income countries.

According to Máté (2014), there is a correlation between a rise in the number of patents and an increase in productivity. Existing substantial z-statistics show that the presence of trademarks is positively connected with increases in levels of productivity. These findings point to the presence of a positive association between intellectual property rights (IPRs) and productivity among the OECD nations that were investigated.

A larger quantity and strength of intellectual property rights in the United States is connected with economic development from 1990 to 2010. The United States of America leads the world regarding both intellectual property rights (IPR) strength and economic growth rate. According to (Heer 2022), United States intellectual property accounts for $6.6 trillion in added value, which is almost 12 times the value of all physical items on a worldwide scale. This number takes into account all types of patents, copyrights, and trademarks. The United States of America is home to a diverse range of patents, particularly those about software. If a product is deemed to have a patent on the functionality of the product, then the functionality of the product cannot be freely replicated, and the rights of the owners are protected. A patent may also provide royalty-free licensing to everyone in the world without imposing any limits on how the licensed product can be used. Patents may be valid for years after they are filed, but in practice, they are valid for twenty years, beginning with the first time the invention was utilized by its creator. Because of the tremendous increase in the expense of producing software over the last two decades, several firms in this area have spent billions of dollars on creating new technologies that may someday need to be patented. The United States of America has a patent system that has been around for a long time and has seen much development, serving as an example for the rest of the globe. The patent laws of the United States have served as a model for the patent laws of many other nations.

China enacted legislation protecting intellectual property rights in electronic data in 2001 (Montgomery & Fitzgerald, 2006). This law was enacted to safeguard the intellectual property rights associated with electronic data. Between 2003 and 2005, this legislation underwent many revisions, resulting in research limitations being placed on some types of media, including radio, films, and publications. The original copyright law suffers from the flaw of not having any provisions that differentiate between originality and imitation (Helpman, 1993). Following the enactment of this legislation, China has seen a surge in the number of patents granted, in addition to an increase in the pace of scientific research. In tandem with the explosive expansion of the media and electronic sectors, the protection of intellectual property rights has emerged as a critical component of ongoing and future research and development.

The legislation protecting intellectual property in India was enacted in 1957. Although the Copyright Act was passed into law in 1962, it did not become fully operational until 1987. (Dhar, 1986). Since 1995, India has been among the most often mentioned nations that grant patents to individuals from other countries. Copyright and patent enforcement in India have steadily improved over the last several years. In recent years, there has been substantial growth in the number of patent applications submitted in the United States, China, and India, yet India ranks only 36th on this list. In the same vein, the protection of intellectual property rights in India is not strictly adhered to.

According to Novotny (2013), stronger patent rights in non-OECD countries serve to ensure a larger transfer of technology across sectors, which in turn will contribute to an expansion of the economy. Countries outside the OECD with stronger patent rights will see a better technology transfer than those without. When technology is moved from its nation of origin to another country, there is a greater chance that it will be diffused and put into use not only in the receiving country but also in other countries. Novotny described that one of the primary objectives of gaining greater patent rights for non-OECD nations is to stimulate knowledge transfer across economies in various development stages. This is one of the major purposes of achieving stronger patent rights for non-OECD countries. Increases in the flow of technology from one economy to another will help all economies advance their levels of knowledge and experience. Transferring inventions from developed countries to developing ones and vice versa is one way to increase the overall level of knowledge and innovation in the world (Novotny, 2013). The study found that stronger patent rights, which include longer intellectual property protection and stronger enforcement of patent rights, are the most important factors for improving technology transfer in countries that are not members of the Organization for Economic Cooperation and Development. Technology transfer will also benefit from the establishment of a system for the resolution of disputes. Increases in patent protection will not only encourage innovation but will also encourage the development of new technologies.

Novotny proved that one of the most important conclusions is that there are significant disparities between the policies of OECD nations and those of non-OECD countries regarding the protection of intellectual property. The research indicates that, in general, non-OECD nations have weaker intellectual property rights (IPR) regimes than OECD countries do.

Despite this, several non-OECD nations have improved their intellectual property rights (IPR) laws and regulations during the last two decades. This tendency is often driven by the desire to align their intellectual property rules with those of nations that are members of the OECD.

From 1985 to 2008, there was a trend toward greater patent rights in nations not members of the OECD. In most non-OECD nations, patents were registered; nevertheless, enforcement was inconsistent owing to inadequate legal systems and other restraints such as corruption. He argued that more stringent patent regimes have a domino effect on other types of intellectual property rights (IPRs), including trademarks, copyrights, and trade secrets. This indicates that greater patent rights have advantages that flow over to other intellectual property rights (IPRs).

The research conducted by Novotny demonstrates, among other things, that the level of GDP per capita is a reliable indicator of IP regimes in emerging nations, but in OECD economies, it is less reliable. These results are consistent with the idea that nations with superior infrastructure and larger national incomes are likely to have stronger intellectual property rights (IPRs).

There is significant diversity across non-OECD nations regarding intellectual property rights (IPR) regimes. In general, the majority of nations that are not members of the OECD do not have a formal patent system (including registration and enforcement).

Summary:

As a conclusion of this chapter, based on the literature, the independent variables related to technology, which are internet access in schools, availability of the latest technology, and FDI technology transfer, as well as property rights as a variable related to institutions, influence economic growth. As mentioned in Chapter 2, most scholars proved these relationships significant and positive. Hence, economists and economic policymakers must consider the trend of technology and the institution matter when investigating economic fluctuations or determining economic indexes.

This chapter shows the important role of technology and institutions in increasing GDP per capita. A higher GDP per capita would be expected if these two variables have a positive trend in an economy.

3 INDUSTRY CLASSIFICATION

3.1 Structure of industry

The goal of industry taxonomies is to provide descriptive data covering the distribution of production and employment across different sectors, the size distribution of enterprises within industries, and the capital-labor ratios in those industries in OECD countries. After that, it summarises the industry structure by presenting many descriptors or taxonomies based on various technology/skill/innovation propensity indicators.

The primary aim of my research is to investigate the relationship between technology and institutions on productivity growth, and the second purpose is to study this relationship in the sectoral approach; therefore, in my estimation, I followed three taxonomies of industries to identify the performance of productivity growth and employment tendency in different labor-skilled branches, the relationship between productivity growth and innovation taxonomy, and finally the relationship between R&D intensities and economic growth, in the recent years. In this regard, I demonstrate a dynamic regression model with cross-industry panel data for each taxonomy to investigate how employment, the level of education, and capital investment affect economic growth in the sectoral approach.

3.2 Taxonomies of industry

Numerous variables can help determine and explain a country's or industry's development. The growth literature emphasizes tangible inputs such as labor and capital and the significance of changes in these inputs' quality and composition. Other literature focuses more on intangible inputs, such as R&D expenditures and innovative activities.

There is no way around making a database with specific information by the business on many or all of these factors. Creating taxonomies, on the other hand, should show how important things like higher ICT capital density or more creative activities are. Taxonomies divide businesses into some groups along a certain axis, like ICT capital intensity, and often only use data from a small number of countries.

According to Van Ark et. al (2003), the following categories are the significant classes of industry structure that might potentially assist in differentiating groupings of sectors and make it easier to conduct a descriptive study of relative performance.

1. **Skill taxonomy** – This taxonomy emphasizes generic labor force skills, with such abilities being determined by educational attainment. Within this taxonomy, four distinct classes range from high to relatively low skill, as mentioned in Table 12.

2. **Innovation taxonomy** – which is based on a description of the primary pathways via which innovation occurs. The Innovation taxonomy classes are mentioned in Table 13.
3. **R&D intensities taxonomy** – This strategy emphasizes technology and classifies businesses into four distinct groups, ranging from high to low levels of technology-intensive operations. The several categories of manufacturing sectors are outlined in Table 14.

3.2.1 Skill taxonomy

A variety of different methodologies have been used in the process of building the skills taxonomy. The advantage of these data is that the breakdown over qualification levels enables a more detailed analysis than much of the data available for larger groups of countries that categorize individuals as being high-skilled or low-skilled (or blue-collar/white-collar or production and non-production workers). Especially for the strategy that goes into great depth, data from EU KLEMS covering all of the nations in the EU in terms of skills were utilized to develop an extra taxonomy. These statistics include several years and workers with high, medium, and low levels of expertise. The following is a definition of the three skill levels: low, medium, and high.

In the case of those who have a low level of skills, those who are graduating from lower secondary education are expected to have fundamental skills, along with a certain degree of speciality. Students are often exempt from further formal schooling requirements when they reach this age. Those with medium abilities have completed their upper secondary school, which takes a minimum of nine years of study at the full-time level, and students often join this level of education between the ages of fifteen and sixteen. Because it encompasses a wide range of different types of occupational training, complete postsecondary education is more difficult to define than secondary education. Tertiary education may be broken down into two broad categories: first-stage tertiary education, which does not lead to an advanced research qualification, and second-stage tertiary education, which does lead to an advanced research qualification).

Table 13
The skill taxonomy of industries
(ISIC Rev 3.)

1. High-skilled (HS): Mineral oil refining, coke, and nuclear fuel (23); Chemicals (24); Of-fice machinery (30); Radio, television and communications equipment (32); Electronic valves and tubes (321); Telecommunication equipment (322); Radio and television receivers (323); Financial intermediation, except insurance and pension funding (65); Insurance and pension funding, except compulsory social security (66); Activities auxiliary to financial intermediation (67); Real estate activities (70); Computer and related activities (72); Research & development (73); Other business services (74); Public administration and defense; compulsory social security (75); Education (80).
2. High-intermediate skilled (HIS): Medical, precision & optical instruments (33); Scientific instruments (331); Other instruments (33-331); Other transport equipment (35); Building and repairing of ships and boats (351); Aircraft and spacecraft (353); Railroad equipment and transport equipment (352+359); Electricity, gas, and water supply (40-41); Air transport (62); Supporting and auxiliary transport activities; activities of travel agencies (63); Communications (64); Renting of machinery & equipment (71); Health and social work (85).
3. Low-intermediate skilled (LIS): Wood & products of wood and cork (20); Pulp, paper & paper products (21); Printing & Publishing (22); Fabricated metal products (28); Mechanical engineering (29); Electrical machinery and apparatus (31); Insulated wire (313); Other electrical machinery & apparatus (31-313); Construction (45); Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel (50); Wholesale trade and commission trade, except motor vehicles and motorcycles (51); Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52); Inland transport (60); Water transport (61).
4. Low-skilled (LS): Agriculture (01); Forestry (02); Fishing (05); Mining and quarrying (10-14); Food, drink & tobacco (15-16); Textiles (17); Clothing (18); Leather and footwear (19); Rubber & plastics (25); Non-metallic mineral products (26); Basic metals (27); Motor vehicles (34); Furniture, miscellaneous manufacturing; recycling (36-37); Hotels & catering (55); Other community, social and personal services (90-93).

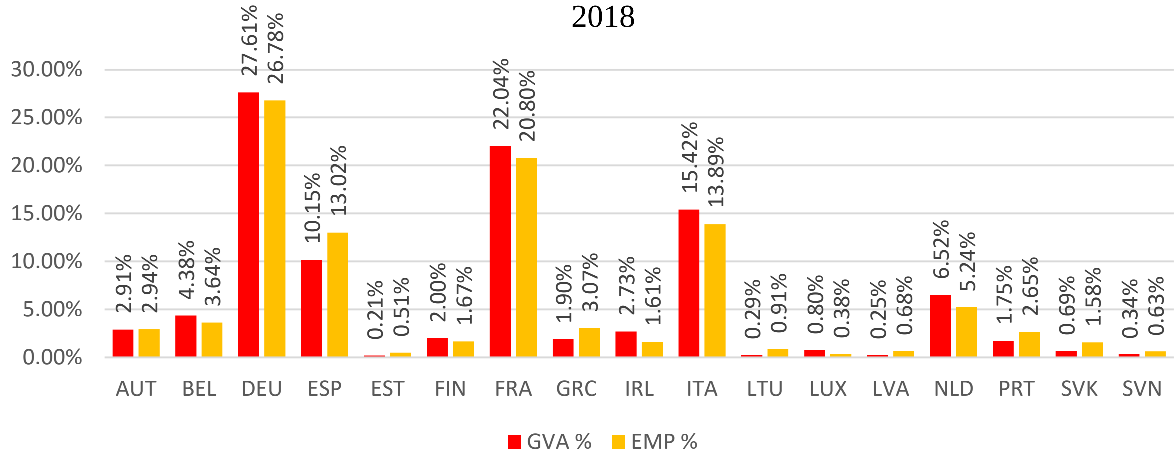
Source: (Mahony & Ark, 2003)

3.2.1.1 Productivity and employment growth tendencies in some of the OECD countries

This section compares the value-added and employment distribution (%) of OECD countries in 2018. The following diagrams indicate each of the four distinct areas of labor-skilled work depicted in Figures 25 through 28.

Figure 25

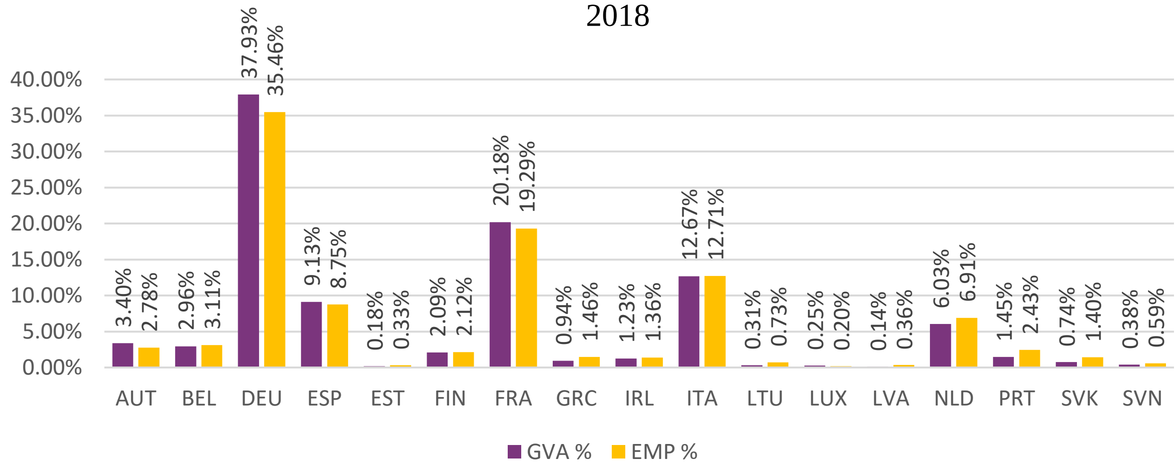
HS Skill taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Figure 26

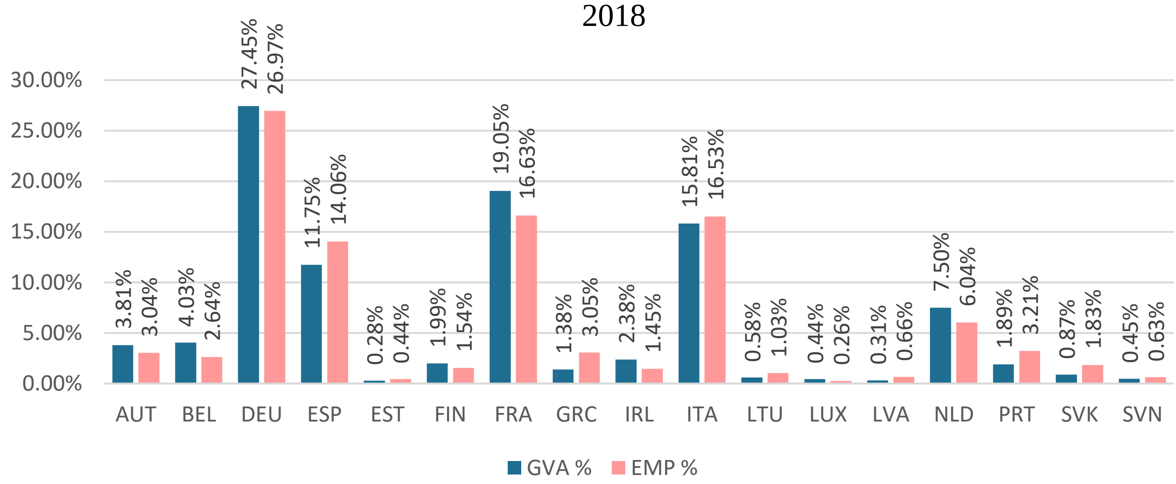
HIS Skill taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Figure 27

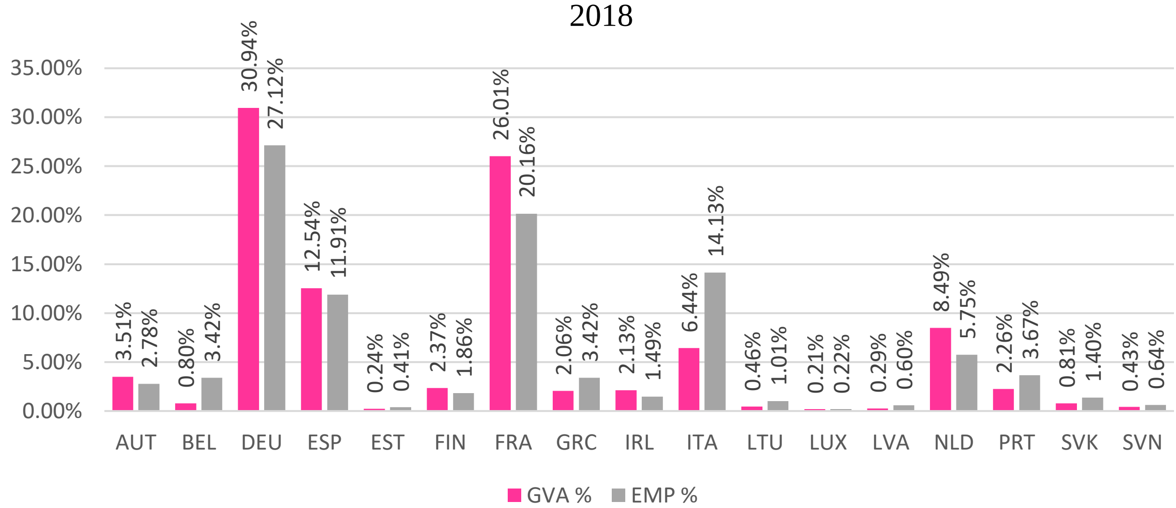
LIS Skill taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Figure 28

LS Skill taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

As shown in the above Figures, the greatest value-added occurred in Germany, France, Italy, Spain, and the Netherlands in all the sectors respectively. The employment rate was greater than value-added in Germany in the HIS sector, which means that a higher employment rate occurred in the high-intermediate skill sector.

For certain nations, such as Spain, the "employment proportion" is almost the same in HS, LIS, and LS, while it has declined in HIS. This scenario is the inverse for Germany, which increased in HIS and was almost the same in HS, LIS, and LS.

Some countries, such as Austria and the Netherlands, have an increase in the proportion of value-added in LIS while they have a lower share of GVA in HS, HIS, and LS.

The following is a condensed format of our findings: while the rates of growth in different countries vary quite a bit from one another, the rate of increase of value-added is relatively stable over extended periods across all industries.

3.2.2 Innovation taxonomy

This taxonomy emphasizes the significant role that innovation plays as a driver of increased levels of productivity. According to substantial evidence gleaned from research carried out at the firm level as well as case studies, complementary innovation activities, such as organizational changes and other non-technological innovations, are of utmost importance in exploiting the productivity potential from investments in technology (ICT) and human capital. This is the case, although technological innovations themselves are of great importance. The construction of the innovation taxonomy that will take place in this section will have the gathering of information on a wide variety of sources of innovation as its primary objective. This taxonomy defines industrial sectors into nine classes as follows:

Table 14
The Innovation taxonomy of industries

1. Supplier Dominated Goods (SDG):

Agriculture (01); Forestry (02); Fishing (05); Textiles (17); Clothing (18); Leather and footwear (19); Wood & products of wood and cork (20); Pulp, paper & paper products (21); Printing & publishing (22); Furniture, miscellaneous manufacturing; recycling (36-37); Construction (45).

2. Scale Intensive industry (SII):

Mining and quarrying (10-14); Food, drink & tobacco (15-16); Mineral oil refining, coke & nuclear fuel (23); Rubber & plastics (25); Non-metallic mineral products (26); Basic metals (27); Fabricated metal products (28); Motor vehicles (34); Building and repairing of ships and boats (351); Aircraft and spacecraft (353); Railroad equipment and transport equipment (352+359); Electricity, gas and water supply (40-41).

3. Specialized Goods Suppliers (SGS):

Mechanical engineering (29); Office machinery (30); Insulated wire (313); Electronic valves and tubes (321); Telecommunication equipment (322); Scientific instruments (331); Other instruments (33-331).

4. Science-Based Innovator (SBI):

Chemicals (24); Other electrical machinery & apparatus (31-313); Radio and television receivers (323).

5. Supplier Dominated Services (SDS):

Retail trade, except for motor vehicles and motorcycles; repair of personal and household goods (52); Water transport (61); Communications (64).

6. Specialized Services Suppliers (SSS):

Computer and related activities (72); Research & development (73); Legal, technical, and advertising (741-3).

7. Organizational Service Innovators (OSI):

Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of automotive fuel (50); Inland transport (60); Air transport (62); Financial intermediation, except insurance and pension funding (65); Insurance and pension funding, except compulsory social security (66) Real estate activities (70); Renting of machinery & equipment (71).

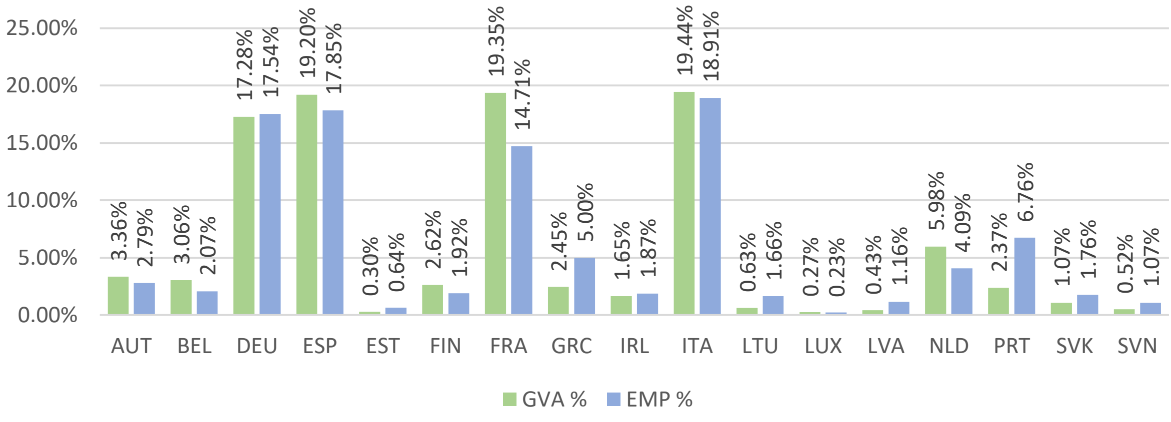
8. Client-Led Services (CLS): Wholesale trade and commission trade, except motor vehicles and motorcycles (51); Hotels and catering (55); Supporting and auxiliary transport activities; activities of travel agencies (63); Activities auxiliary to financial intermediation (67); Other business services (749); Other Community, social, and personal services (90-93); Private households with employed persons (95);
9. Non-Market Services (NMS): Public administration (75); Education (80); Health (85).

Source: (Mahony & Ark, 2003)

3.2.2.1 Productivity growth and innovation tendencies in some of the OECD countries

Figure 29

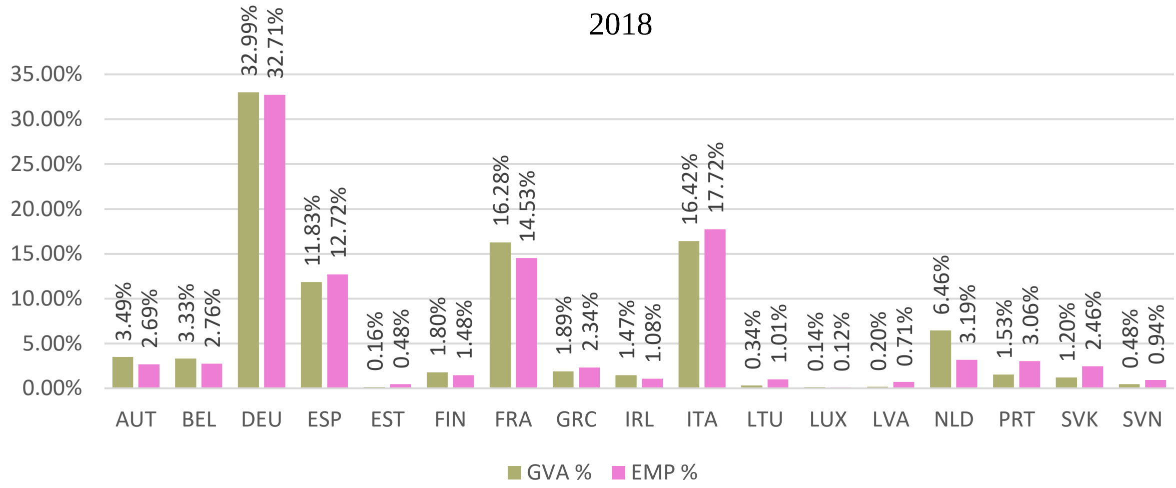
SDG innovation taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Figure 30

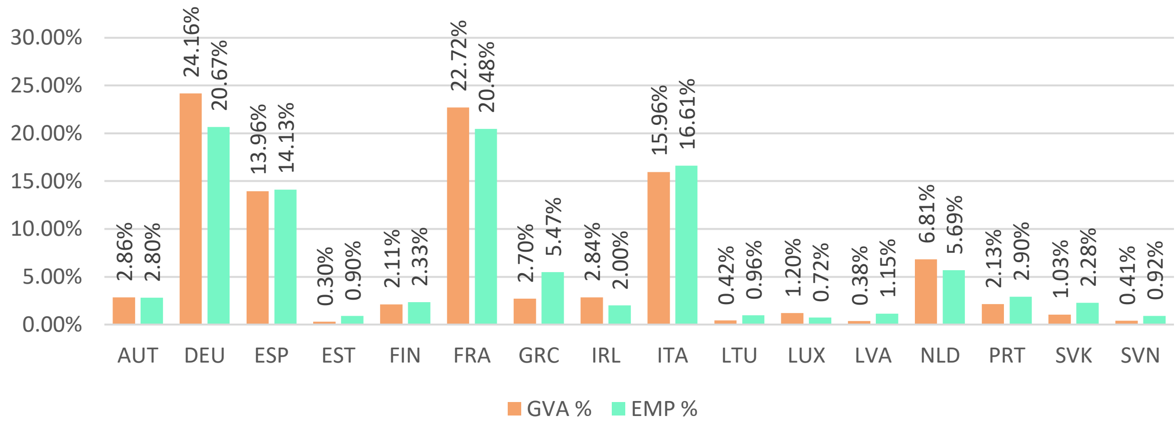
SII innovation taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Figure 31

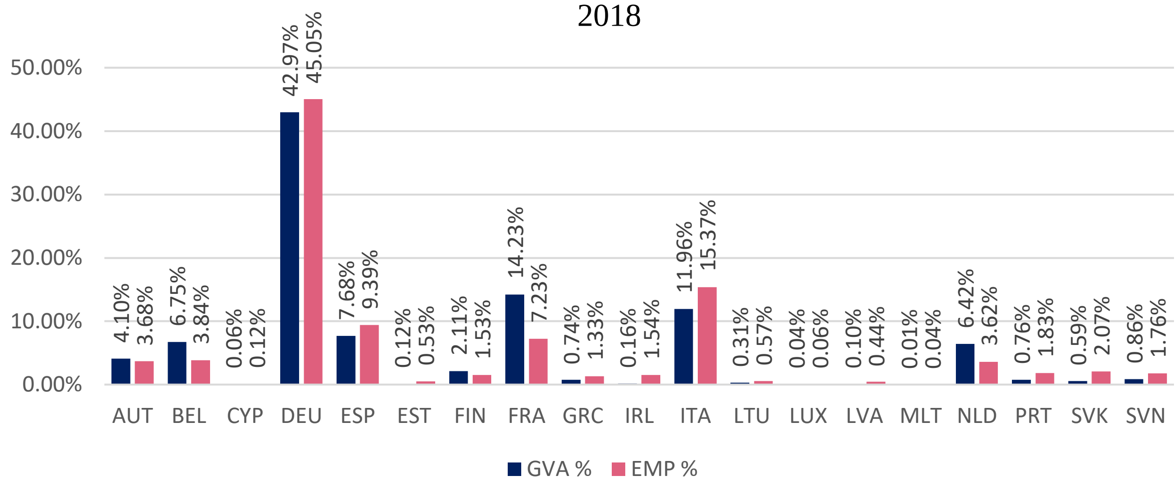
SGS innovation taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Figure 32

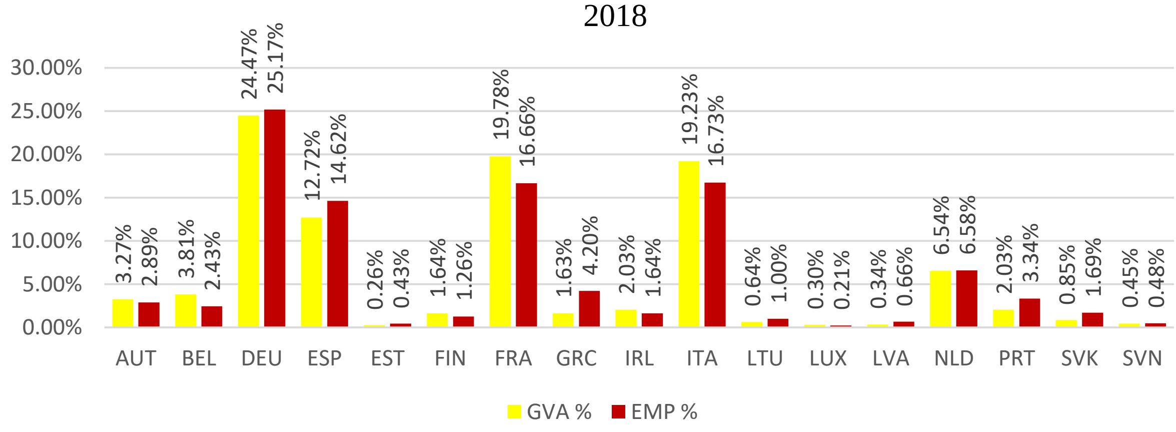
SBI innovation taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Figure 33

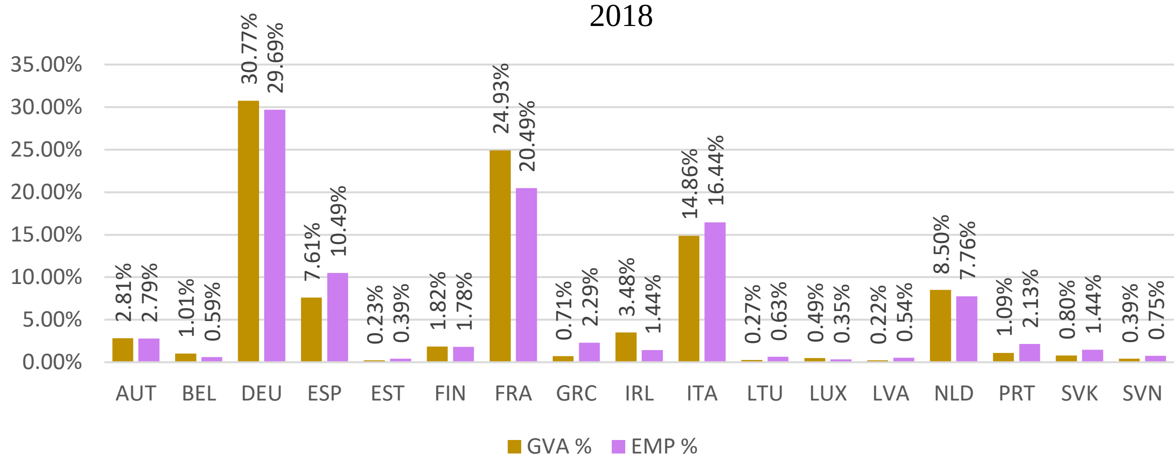
SDS innovation taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Figure 34

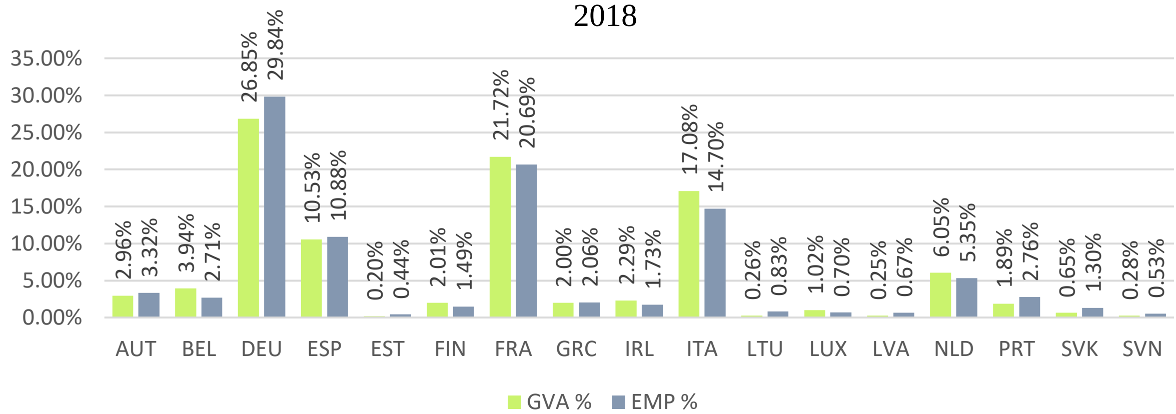
SSS innovation taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Figure 35

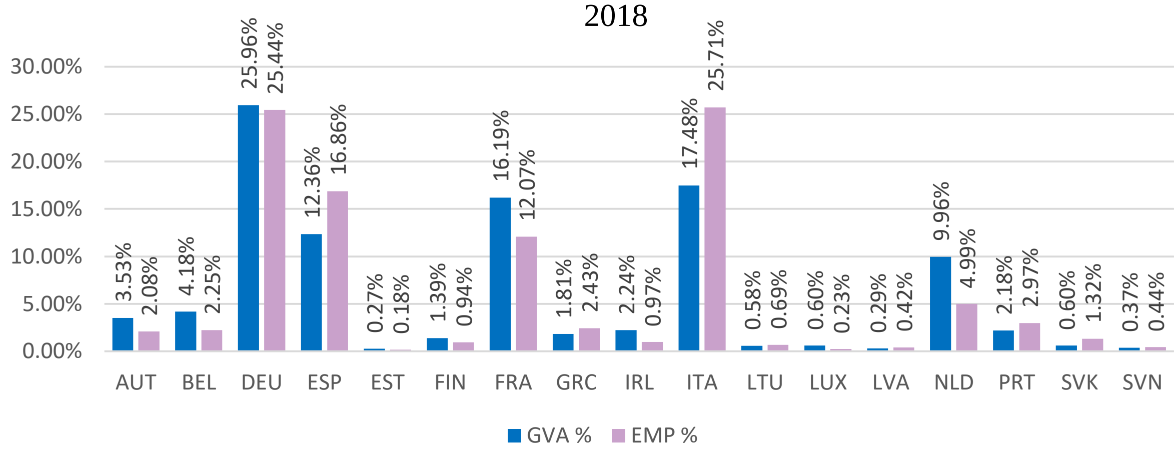
OSI innovation taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Figure 36

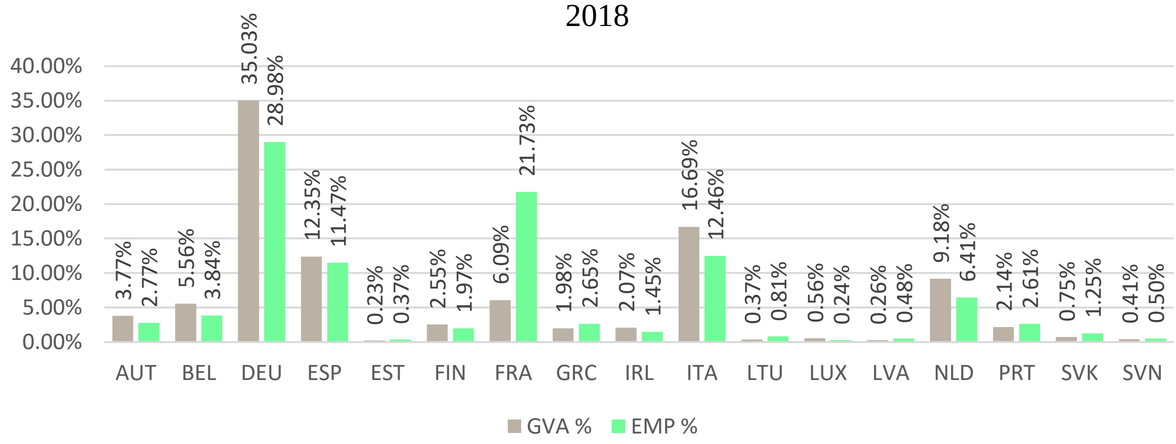
CLS innovation taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Figure 37

NMS innovation taxonomy
Gross Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on EU KLEMS (2022)

Germany has the highest shares of value-added as well as Employment among the OECD countries in most of the sectors. The value-added and employment proportions of France, Italy, and the Netherlands are at the second, third, and fourth ranks, respectively. Hence, these countries can be considered holders of high innovation tendencies compared with the other OECD countries.

In SBI, Belgium's employment share is more than 50%, and the other countries have less than 50%, which means that most of the human capital is allocated to this sector in Belgium. Germany is the first country again, but France, Italy, and the Netherlands' proportions are so low.

In all the sectors, Germany's value-added share is greater than its employment share, except in the SDS and NMS sectors.

The value-added share and the Employment proportion of Austria, Cyprus, Spain, Estonia, Finland, Greece, Hungary, Croatia, Ireland, Lithuania, Luxemburg, Latvia, Portugal, Slovakia, and Slovenia are almost the same in all the sectors. As a result, these countries have harmony in all the innovation tendencies sectors.

3.2.3 R&D intensities taxonomy

In this sector, I followed a unique taxonomy initially presented by Hatzichronoglou (1997) to determine the primary characteristics of production per capita growth tendencies. This taxonomy was designed to categorize different types of economic growth. This strategy emphasizes technology and classifies industries into four distinct groups, ranging from those with a high to a low level of technological intensity.

This taxonomy strongly emphasises the R&D intensities that play in its capacity as a driver of improved levels of productivity.

I used OECD STAN database (2020 edition) for R&D intensities taxonomy and collected ’VALU” and ’EMPN” of some the OECD countries from 2008 to 2018.

Table 15
Classification of manufacturing industries into categories
based on R&D intensities

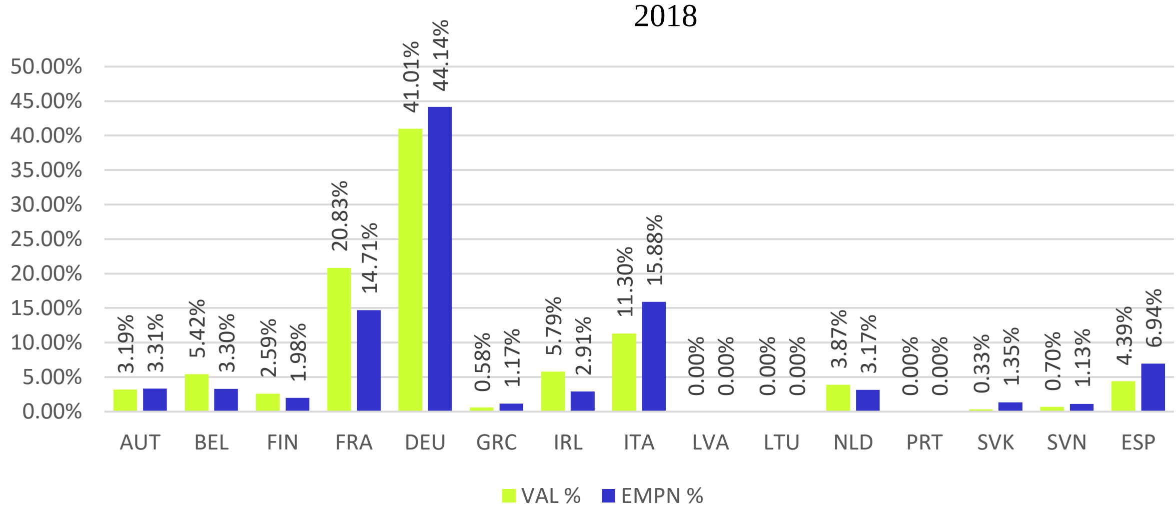
1. High Technology Industries (HT): Aircraft and spacecraft Pharmaceuticals Office, accounting, and computing machinery Radio, TV, and communications equipment Medical, precision, and optical instruments
2. Medium-High Technology Industries (MHT): Electrical machinery and apparatus, n.e.c. Motor vehicles, trailers, and semi-trailers Chemicals excluding pharmaceuticals Railroad equipment and transport equipment, n.e.c. Machinery and equipment, n.e.c.
3. Medium-Low Technology Industries (MLT): Building and repairing ships and boats Rubber and plastic products Coke, refined petroleum products, and nuclear fuel Other non-metallic mineral products
4. Low Technology Industries (LT): Manufacturing, n.e.c.; Recycling Wood, pulp, paper, paper products, printing, and publishing Food products, beverages, and tobacco Textiles, textile products, leather, and footwear

Source: (Hatzichronoglou, 1997)

3.2.3.1 Productivity growth and R&D intensities in some of the OECD countries

Figure 38

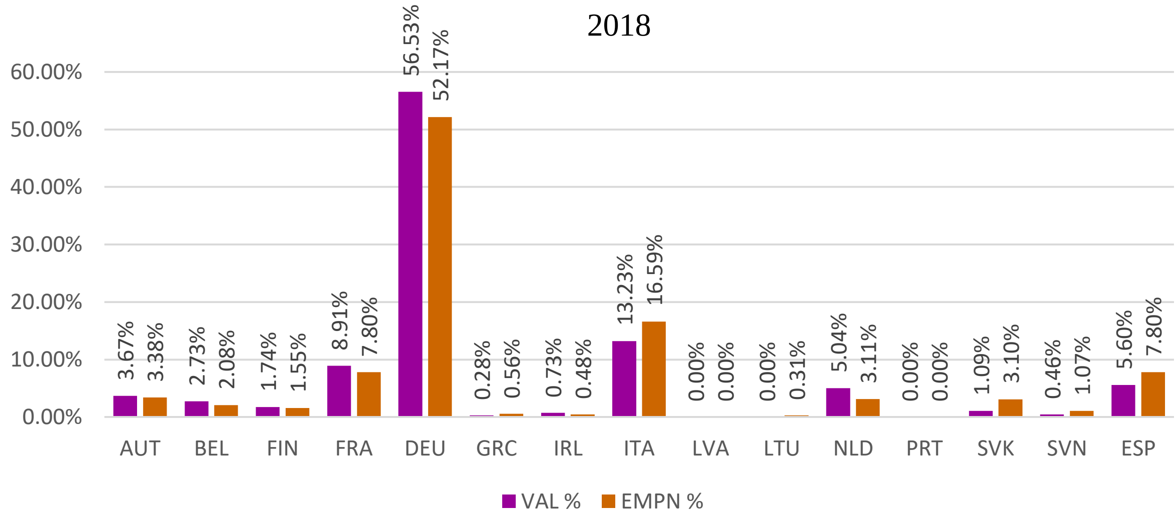
HT R&D intensities taxonomy
Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on OECD STAN database (2022)

Figure 39

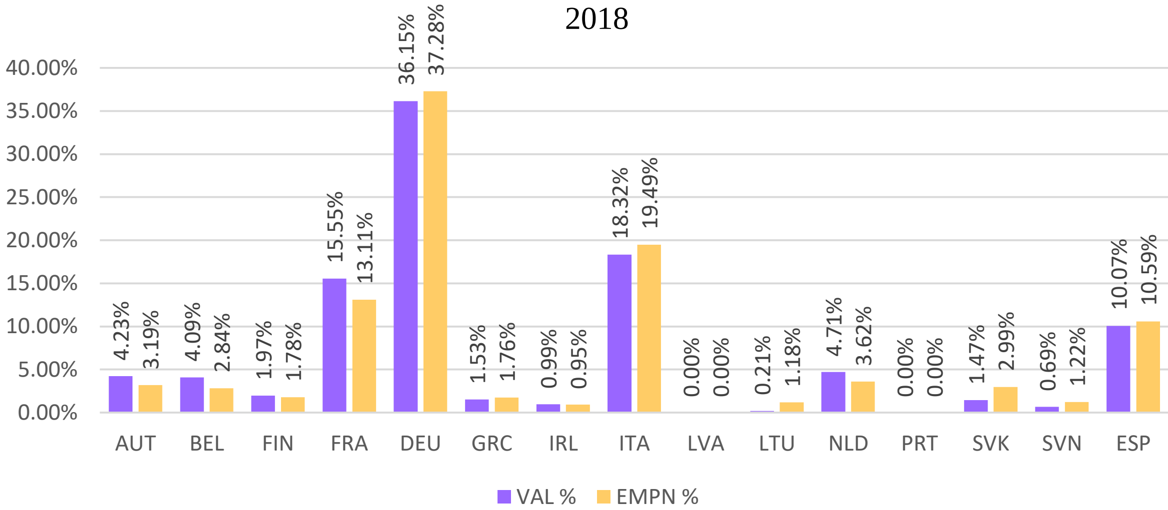
MHT R&D intensities taxonomy
Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on OECD STAN database (2022)

Figure 40

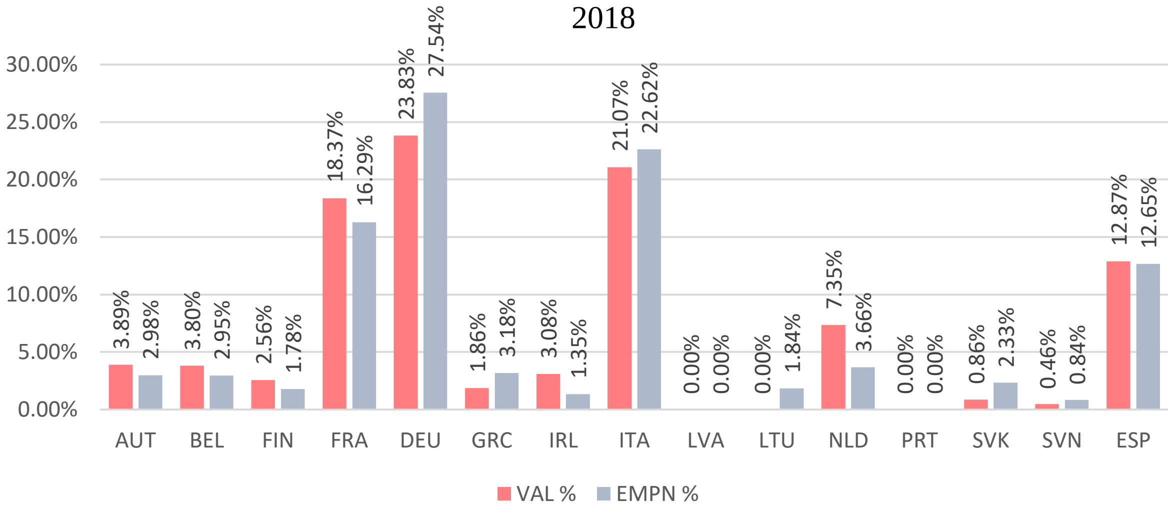
MLT R&D intensities taxonomy
Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on OECD STAN database (2022)

Figure 41

LT R&D intensities taxonomy
Value added percentage and Employment Growth percentage,
Some of the OECD countries
2018



Source: Author's calculation based on OECD STAN database (2022)

2 MATERIAL AND METHODS

2.1 Data Collection

Economies are classified into many groups, such as developed versus developing nations with certain socio-economic characteristics. A high level of export diversification, a high degree of financial system integration, a large level of industrialization, and a high gross domestic product per capita are frequently the hallmarks of a developed market (Mody, 2004). In the meantime, a developing nation is making strides toward becoming an advanced country. This nation already has a physical, financial infrastructure comprising banks, a stock exchange, and unified currencies. However, this nation's market efficiency, accounting standards, and securities regulations are not yet on par with those of developed nations.

However, institutions evaluate the growth of a nation in many different ways to serve the demands of investors with an objective and consistent approach to the categorization of markets, and there is no precise agreement on how these markets should be categorized.

In this research I used some of the OECD countries data, reported by the OECD organization, as mentioned in the Introduction section. The data were collected from the years 2008 to 2018 from some of the OECD countries. It was done so that the findings obtained for each category would be more reliable.

A database known as the World Development Indicators (WDI) has been developed by the World Bank to facilitate the collection of pertinent statistics of high quality and global comparability about global development and the struggle to eradicate poverty. This Databank (The World Bank) strives to construct a balanced panel by including measurements of factors like production per capita, employment, capital formation, and other such things at the level of individual countries beginning in 1960 and continuing forward. The database maintained by the World Economic Forum is the source of information on access to Internet technologies and infrastructure characteristics (World Economic Forum).

Internet connectivity in schools, availability of the latest technology, FDI and technology transfer, and property right are used from the Global Competitiveness Index dataset (GCI).

In my research, the EU KLEMS database has been used for skill taxonomy as well as innovation taxonomy. This database contains information on value-added and employment rates for OECD countries, contains 56 different sectors between 1980 and 2021.

The new OECD STAN Database used for R&D intensities taxonomy. In this database, the national accounts has served as the point of departure for the majority of the world's countries.

The OECD STAN Database includes information on the most significant national accounts from 1970 onwards based on standard industry classification.

The data series available from STAN is the value added in current and constant prices (at basic prices), numbers of persons engaged (including self-employed), number of employees, total labor compensation, and, in a limited number of cases, working hours. Similar variables were available from survey statistics.

2.2 Methodology

Those who disagree with the initial version of Solow's model, which did not account for human capital, point out the inconsistencies between the facts and the model's predictions. A significant overestimation of the rate at which economies will converge to a steady-state level, in contrast to a significant underestimation of the rate at which economies save money and increase their populations. Both of these empirical flaws are amenable to having their severity reduced by increasing the amount of human capital.

As a direct consequence of this, the first point of view is a classical Cobb-Douglas production function. If we assume that human capital is employed to create technology, which then translates into the accumulation of physical capital, then the level of their stock will determine the growth rate of the economies (Romer, 1990). In this method, the amount of human capital is what influences the growth rate, and this is done via the parameter for the neutral total factor productivity. In less developed and rising nations, the connection that predominates is consistent with the technique outlined by (Lucas, 1988). Therefore, the accumulation of human capital that affects economic growth can be better modeled as a factor of production (van Leeuwen & Foldvari, 2008). by the aggregate income [Yt] in period t. At the same time, the amounts of physical capital [Kt] and labor [Lt] can be extended by human capital [Ht], which is predetermined by previous accumulation:

$$Y_t = K_t^{\propto} H_t^{\gamma} (A_t L_t)^{1-\propto-\gamma} \quad (1)$$

In situations in which the notation serves as the standard. The production function (1) assumes constant returns to scale (0<α<1, 0<γ<1), where [At] is the variable representing the technology, and it follows an exogenous route of a constant [g] growth rate of technological development. As a result, At = Ao(1+g)t for all t. According to Mankiw et al. (1992), divide both sides of the equation (1) by [Lt] and then use the conventional definition of output per worker, which is yt= Yt/Lt. As a result, the production function based on per capita output is altered as follows:

$$y_t = k_t h_t {A_t}^{1-\propto-\gamma} \tag{2}$$

The rate of investment in physical capital [sk], the rate of investment in human capital [sh], and the rate of employment growth [n] are all stated to compute the steady-state level of productivity [y*]. Therefore, under the assumption that there is not a compelling reason to anticipate depreciation rates [δ] and that [g] reflects the rate of long-run technological change, which can significantly vary from country to country, a constant value of 0.05 was substituted for and added to employment growth (n+δ+g). The steady-state level of productivity follows after the arrangement:

$$y *_t = A_t (\frac{s_k}{n+\delta+g})^{\propto/(1-\propto-\gamma)} (\frac{s_h}{n+\delta+g})^{\gamma/(1-\propto-\gamma)} \tag{3}$$

The logs of both sides of the equation have been taken to do an empirical test of (3) about the steady-state prediction. At this point, the relationship between the explanatory variables is linear:

$$lny *_t = lnA_t + \frac{\propto}{(1-\propto-\gamma)} [lns_k + (n+\delta+g)] + \frac{\gamma}{(1-\propto-\gamma)} [lns_h - (n+\delta+g)] \tag{4}$$

After adjusting for return to scales, g and δ are constant (0.05) across [i] countries (4) and may be recast and reorganized into a formula for linear regression, which is as follows:

$$lny_{i,t} *= \beta_o + \beta_1 lns_{k_{i,t}} + \beta_2 ln(n+\delta+g)_{i,t} + \beta_3 lns_{h_{i,t}} + \beta_4 lnA_{i,t} + \varepsilon_{i,t} \tag{5}$$

where the dependent variable ln $y_{i,t}$ is the log of GDP per capita in constant value; ln $sk_{i.t}$ signifies an indicator of gross capital creation per GDP; ln(n+δ+g) is calculated by the sum of employment growth rates and 0.05; ε is the error term.

2.3 Model specification

The consideration of endogenous growth theories has been expanded across the empirical study via the use of dynamic techniques for a limited number of periods and cross-sectional analyses (Arellano & Bond, 1991). The economy tends to move toward long-term equilibrium when this dynamic strategy is used. In most cases, the lagged levels of the dependent and predefined variables among the repressors are used in these kinds of methodologies. Extraordinary instrumentation of these lagged endogenous variables is necessary for a dynamic specification, and GMM estimators must be reflected such that they can account for covariates. As a result, internal instruments are used since some of the lagging explanatory factors may affect the variable that is being investigated to rule out biases. The number of instruments has been restricted to prevent the issue of overestimation (Roodman, 2009).

In the case of developing markets, the following formula is evaluated after calculating the logarithm of the initial differences of the dependent productivity variable: The following is a transformation based on the previous equation (5):

$$\Delta lny_{i,t} *= \beta_o + \beta_1 lny_{i,t-1} + \beta_2 lns_{k_{i,t}} + \beta_3 ln(n+\delta+g)_{i,t} + \beta_4 lnInternet\_Access_{i,t} + \beta_5 lnAvailability_{i,t} + \beta_6 lnFDI_{i,t} + \beta_7 lnProperty_{i,t} + \beta_8 \varepsilon_{i,t} \quad (6)$$

The dependent variable is the first log of GDP per capita of the country [i] for the period [t] at a constant value. The log of the dependent variable, the investment ratio in physical capital, the growth of employment, the internet access in education, the latest available technologies, FDI and technology transfer, and property rights are the independent variables, respectively.

The Table 16 is presented in the order in which the independent variables appear.

2.4 Model's validity

Why do I use GMM estimation for my research?

According to Wooldridge (2001), GMM has significant advantages over maximum likelihood in this context because GMM allows estimation under the restrictions implied by the theory; there is no need to add distributional assumptions that are not implied by the theory.

The GMM model, mostly used for panel data, provides consistent results in the presence of different sources of endogeneity, namely “unobserved heterogeneity, simultaneity, and dynamic endogeneity” (Wintoki et al., 2012).

It was found that the two-step GMM analysis method is suitable to handle the assumption of biased standard errors and to prove the validity of comparisons.

In all the models, the Sargan-Hansen tests illustrate the results of over-identifying limitations. The Sargan-Hansen test is used to avoid instrument proliferation where there is a correlation between the instruments and the errors; to avoid that, the Sargan-Hansen test has been used; otherwise, it leads to misleading results. Also, Autocorrelation can be considered as the Arellano–Bond test (AR2). The p-value of the Arellano–Bond test should be higher than 0.05

(Arellano & Bond, 1991). Based on the results shown in the next section, the two-step GMM analysis method is used to estimate and predict the model used in this study.

Table 16

Description, Abbreviations, and Sources of Main Variables

Variable	Abbreviation	Description	Source
GDP per person employed	y	GDP per person employed is gross domestic production (GDP) divided by total employment in the economy.	EU KLEMS And STAN database
Capital stock at a current price	Sk	Share of investment within sectoral output	Penn World Table
Human capital	hc	Based on the years of schooling and returns to education.	Penn World Table
Total employment (ages 15+)	$n + \delta + g$	Total employment shows the total number employed ages 15 and over.	EU KLEMS And STAN database
Quality of education	ias	Internet access in schools, 1-7 (best)	GCI data series
Technology adoption	alt	Availability of the latest technologies	GCI data series
FDI and technology transfer	Fdi_tt	FDI and technology transfer	GCI data series
Property rights	pr	Security of property rights Patents, Trademarks, Industrial designs	GCI data series

Source: Author's compilation (2022)

3 RESEARCH FINDINGS, EVALUATION, AND DISCUSSION

3.1 Results of Skill taxonomy of industries

The descriptive statistics (Mean, Standard Deviation, Minimum, and Maximum) and correlation of the examined variables are reported by observations. The samples consist of a strongly balanced panel of OECD countries from 2008 to 2018.
All of the underlying variables are in their original measure.

3.1.1 Results of High Skill (HS)

Descriptive Statistics of High Skill (HS)

Table 17
Descriptive Statistics of the Examined Variables

Skill taxonomy- High Skill

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	4.4124	0.5535	3.2763	5.4642
Physical capital	187	14.3050	1.5135	11.7654	16.7764
Employment growth	170	0.0548	0.0178	-0.0415	0.0910
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author’s compilation (2022)

Correlation Matrices of High Skill (HS)

Table 18
Correlation Matrices for Examined Variables

Skill taxonomy- High Skill

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools**.**	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.4482	1						
Employment growth	0.1302	-0.1955	1					
Human capital	0.2174	-0.293	0.2918	1				
Internet access in schools	-0.143	-0.5104	0.2457	0.4673	1			
Availability of the latest technologies	0.4651	0.1093	0.1738	0.5052	0.6302	1		
FDI technology transfer	0.2152	-0.2054	0.2299	0.3334	0.3033	0.4191	1	
Property rights	0.6184	0.0851	0.0595	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of High Skill (HS)

This test checks whether the time series has a unit root problem. Unit root in the model means that there are shocks that cannot be controlled. (i.e. random walk drift).

On the other hand, it is important to be sure that the model is stationary (i.e. statistics, such as variants and mean, are constant during a specific time in the model).

There are several methods of unit root tests, such as the following:

1. Hadri LM stationarity
2. Levin-Lin-Chu
3. Harris-Tzavalis
4. Breitung
5. Im-Pesaran-Shin
6. Fisher-type

To check the existence of the unit root problem, I used the “Hadri LM stationarity” method in which the Ho and Ha should be as follows:

Ho: Panels contain unit roots (i.e. there is a unit root problem)

Ha: Panels are stationary (i.e. there is no unit root problem)

Generally, based on the literature, if the p-value is less than 0.05, this means that the panel data does not contain the unit root test (Ho should be rejected).

Table 19

Unit-Root Test (**Hadri LM**) for GDP per person employed

Skill taxonomy- High Skill

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Ho: All panels are stationary		Number of panels =	17
Ha: Some panels contain unit roots		Number of periods =	11
Time trend:	Not included	Asymptotics: T, N -> Infinity sequentially	
Heteroskedasticity: Not robust			
LR variance:	(not used)		

	Statistic	p-value
z	19.2711	p<0.001

Ho is rejected.

Based on the unit root test, if the p-value is less than 0.05, this means that the panel data does not contain the unit root test (Ho should be rejected).

As shown in the above tables, the p-value is less than 0.05.

As a result, the HS class of Skill taxonomy does not contain a unit root problem.

3.1.2 Results of High-Intermediate Skill (HIS)

Descriptive Statistics of High-Intermediate Skill (HIS)

Table 20

Descriptive Statistics of the Examined Variables

Skill taxonomy- High-Intermediate Skill

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	3.8240	0.4238	2.8083	4.3675
Physical capital	187	14.3050	1.5135	11.7654	16.7764
Employment growth	170	0.0600	0.0261	-0.0629	0.1309
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of High-Intermediate Skill (HIS)

Table 21

Correlation Matrices for Examined Variables

Skill taxonomy- High-Intermediate Skill

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools.	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.5713	1						
Employment growth	0.2691	-0.0183	1					
Human capital	0.1684	-0.293	0.2346	1				
Internet access in schools	-0.2278	-0.5104	0.2136	0.4673	1			
Availability of the latest technologies	0.4247	0.1093	0.3343	0.5052	0.6302	1		
FDI technology transfer	0.1061	-0.2054	0.1713	0.3334	0.3033	0.4191	1	
Property rights	0.5478	0.0851	0.0896	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of High-Intermediate Skill (HIS)

Table 22

Unit-Root Test (**Hadri LM**) for GDP per person employed

Skill taxonomy- High-Intermediate Skill

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Ho: All panels are stationary		Number of panels =	17
Ha: Some panels contain unit roots		Number of periods =	11
Time trend:	Not included	Asymptotics: T, N -> Infinity	
Heteroskedasticity: Not robust			sequentially
LR variance:	(not used)		

	Statistic	p-value
z	19.3297	$p<0.001$

Ho is rejected.

3.1.3 Results of Low-Intermediate Skill (LIS)

Descriptive Statistics of Low-Intermediate Skill (LIS)

Table 23

Descriptive Statistics of the Examined Variables

Skill taxonomy- Low-Intermediate Skill

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	3.7228	0.4602	2.8065	4.5399
Physical capital	187	14.3050	1.5135	11.7654	16.7764
Employment growth	170	0.0429	0.0352	-0.1632	0.2121
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of Low-Intermediate Skill (LIS)

Table 24

Correlation Matrices for Examined Variables

Skill taxonomy- Low-Intermediate Skill

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools**.**	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.3487	1						
Employment growth	0.3461	0.0323	1					
Human capital	0.3943	-0.293	0.2292	1				
Internet access in schools	0.1202	-0.5104	0.2366	0.4673	1			
Availability of the latest technologies	0.6362	0.1093	0.2773	0.5052	0.6302	1		
FDI technology transfer	0.2984	-0.2054	0.09	0.3334	0.3033	0.4191	1	
Property rights	0.6998	0.0851	0.0323	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of Low-Intermediate Skill (LIS)

Table 25

Unit-Root Test (**Hadri LM**) for GDP per person employed

Skill taxonomy- Low-Intermediate Skill

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Ho: All panels are stationary   Number of panels = 17

Ha: Some panels contain unit roots   Number of periods = 11

Time trend: Not included   Asymptotics: T, N -> Infinity

Heteroskedasticity: Not robust   sequentially

LR variance: (not used)

	Statistic	p-value
z	19.9839	p<0.001

Ho is rejected.

3.1.4 Results of Low Skill (LS)

Descriptive Statistics of Low Skill (LS)

Table 26

Descriptive Statistics of the Examined Variables

Skill taxonomy- Low Skill

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	3.4157	0.5384	2.2668	4.1800
Physical capital	187	14.3050	1.5135	11.7654	16.7764
Employment growth	170	0.0526	0.0180	-0.0457	0.0889
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of Low Skill (LS)

Table 27

Correlation Matrices for Examined Variables

Skill taxonomy- Low Skill

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools**.**	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.3462	1						
Employment growth	0.2787	0.0639	1					
Human capital	0.3047	-0.293	0.3425	1				
Internet access in schools	0.0292	-0.5104	0.1466	0.4673	1			
Availability of the latest technologies	0.4383	0.1093	0.3606	0.5052	0.6302	1		
FDI technology transfer	0.1737	-0.2054	0.2106	0.3334	0.3033	0.4191	1	
Property rights	0.5564	0.0851	0.2257	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of Low Skill (LS)

Table 28

Unit-Root Test (**Hadri LM**) for GDP per person employed

Skill taxonomy- Low Skill

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Ho: All panels are stationary		Number of panels =	17
Ha: Some panels contain unit roots		Number of periods =	11
Time trend:	Not included	Asymptotics: T, N -> Infinity sequentially	
Heteroskedasticity: Not robust			
LR variance:	(not used)		

	Statistic	p-value
z	21.0405	$p<0.001$

Ho is rejected.

3.1.5 Results of regression of Skill taxonomy

Table 29
Results of regression – Innovation taxonomy of industries
Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Independent variable	Model 1				Model 2			
	HS	HIS	LIS	LS	HS	HIS	LIS	LS
Constant	-1.2414	-0.1172	-2.9354	-1.3604	-0.7573	0.8702	-2.0132	-1.2863
	(-2.59)**	(-0.29)	(-6.49)***	(-5.08)***	(-1.51)	(0.80)	(-1.38)	(-2.22)**
GDP per person employed	0.7518	0.7084	0.5689	0.8191	0.4764	0.3661	0.6760	0.8445
	(13.05)***	(11.07)***	(17.02)***	(21.73)***	(6.30)***	(3.13)***	(9.52)***	(10.30)***
Physical capital	0.1470	0.0645	0.2860	0.1316	0.1726	0.1132	0.1747	0.1217
	(3.72)***	(2.01)**	(7.81)***	(6.14)***	(4.35)***	(2.37)**	(2.37)**	(2.95)***
Employment growth	-0.5059	-0.4341	-0.1513	-0.5506	-0.5164	-0.5706	-0.0862	-0.3641
	(-2.64)***	(-6.86)***	(-1.85)*	(-7.37)***	(-3.68)***	(-1.88)**	(-0.82)	(-0.81)
Human capital	0.0702	0.0984	0.1279	0.0404	0.1882	0.1008	0.0445	0.0103
	(1.55)	(2.49)**	(4.32)***	(3.26)***	(3.90)***	(2.07)**	(0.52)	(0.19)
Internet access in schools	#	#	#	#	-0.1171	-0.1561	-0.1289	-0.0160
	#	#	#	#	(2.67)***	(1.62)	(-0.84)	(-0.30)
Availability of the latest technologies	#	#	#	#	0.0148	0.0518	0.4800	0.0789
	#	#	#	#	(0.42)	(0.26)	(3.59)***	(0.89)
FDI and technology transfer	#	#	#	#	0.1033	-0.0452	0.1890	-0.0181
	#	#	#	#	(3.41)***	(0.25)	(0.33)	(0.19)
Property rights	#	#	#	#	-0.0178	-0.0793	-0.2314	-0.0092
	#	#	#	#	(-0.36)	(0.36)	(-1.52)	(-0.09)
Observations	153	153	153	153	153	153	153	153
Countries	17	17	17	17	17	17	17	17
Instruments	13	49	49	49	17	53	53	53
Wald test	(1737.10)***	(1035.43)***	(3665.86)***	(9690.66)***	(1035.04)***	(269.84)***	(5270.41)***	(6622.49)***
AR(1) test	(-1.0552)	(-1.3643)	(-1.1669)	(-2.1897)**	(0.6324)	(-1.0178)	(-1.3482)	(-2.1757)**
AR(2) test	(-1.3860)	(-1.9867)**	(-1.3911)	(-1.2684)	(-0.8658)	(-2.2233)**	(-1.5452)	(-1.1111)
Sargan test	(14.3063)*	(15.2534)	(15.3316)	(14.1327)	(12.8200)	(5.5255)	(13.6653)	(12.5352)

Source: Author's compilation (2022)
Note: P<0.01 ***, P<0.05 **, P<0.1 *

3.1.6 Evaluation and discussion of the Skill Taxonomy results

Table 29 represents the corresponding results for Skill taxonomy.

In this table, I find that there is a valid dynamic representation of the relationship between the measure of employment, human capital, and productivity growth. The impact of the GVA is robust, and there are highly significant positive z-statistics. If an increase happens in the share of investment within the GDP [s_k] variable in both models, as theoretically expected, we could claim that all the models have a positive and highly significant impact on productivity growth. This result matches the scientific work of Stiroh & Tel (2000). According to this research, productivity growth, in particular, is important since it is consistent with the idea that the massive investment in new technology is working to improve the performance of the banking industry. Tangible investment increases output and boosts living standards by providing employees with greater capital and enhancing labor productivity. Because of the importance of investment, there has been a great deal of theoretical and empirical study on the link between investment, productivity, and economic growth. According to the theory, Employment negatively correlated to productivity growth in all the classes, as well as productivity growth has a significant association with Employment in some sectors. Based on the literature, Melamed et al. (2011) suggest that growth in services is becoming relatively more important in driving employment than manufacturing. The authors looked at research on 24 growth episodes from the 1980s, 1990s, and 2000s, in which there was evidence of the impact of employment in different sectors. In 18 of these, poverty had fallen. In 15 of these cases, there had been a rise in employment in services, in 10 a rise in industrial employment, and in six cases a rise in employment in agriculture (six saw rises in employment in two of the three sectors, but there was no case of increased employment in all three sectors). Similarly, Kapsos (2005) found that historical global employment elasticities by economic are highest in services (at 0.61 percent) at the global level; he estimates that between 1991 and 2003, total employment increased by 0.3 to 0.38 percentage points for every one percentage point of extra GDP growth. Kapsos's study mainly focuses on different regions (including the Soviet Union, East Asia, Mexico, the developed world, Argentina, and the Russian Federation) in different periods. As we can see in the results, as indicated in much of the literature, an increase in the level of human capital results in an increase in GDP per capita growth in all sectors. Hence, human capital is controversially correlated with productivity growth in these sectors. Based on the neoclassical growth theories, such as Mankiw G. et al. (1992), there is a positive relationship between human capital and productivity growth. Although scholars have proven, this relationship can be negative in the case of some countries (Máté, 2015). However, in this research, the impact of human capital on productivity growth is significant in most of them. The significance means that more Human capital, ceteris paribus, implies productivity growth. As regards Internet access in schools, it has a negative impact on productivity growth. In other words, for every one-unit increase in internet access in schools, there is an decrease in productivity by -0.1171, -0.1561, -0.1289, and -0.0160 for HS, HIS, LIS, and LS, respectively. Therefore, this result doesn't matche the scientific work of (Karaçor et al., 2018), who conclude that the Internet in schools positively affects economic growth and enhances the level of quality of education, which is necessary for productivity. The results shows that there is a positive relationship between productivity growth and availability of the latest technology in all the sectors. In this case, scholars proved that the positive effect of the latest technological adoptions is robust (Borensztein et al., 1995) and the role of the transfer and diffusion of new technologies on productivity growth is important (Postelnicu & Dabija, 2015). Regarding FDI and technology transfer variable, there is a positive relationship between FDI & technology transfer and productivity growth in HS and LIS, but this effect is negative in HIS and LS. In the meantime, it is significant in HS only. However, based on the literature, the relationship is positive most of the time, where FDI and technology transfer enhance productivity. A case study of the energy done by Osano & Koine (2015) in Kenya proved that FDI & technology transfer have an important relationship with economic growth. The beneficial impacts of FDI are mostly due to the transfer of technology, knowledge, and other intangible assets, which result in increased productivity and improved resource allocation efficiency (Khawar, 2005). Property rights have a negative relationship and not significant effect on productivity growth in all sectors. This result doesn't matche with some of the previous studies where property rights should have a positive effect on productivity. For example, based on the study of Sattar and Mahmood (2011), intellectual property rights contribute to economic growth positively and significantly worldwide. Further, by classifying the entire sample of countries into high-income, upper-middle-income, lower-middle-income, and low-income countries, they have found that the impact is greater in high-income countries than in middle and low-income countries. Moreover, it also concludes that the impact of intellectual property rights on economic growth is more effective in upper-middle countries than lower-middle-income countries, which in turn is stronger compared to low-income countries.

3.2 Results of Innovation taxonomy of industries

3.2.1 Results of Supplier Dominated Goods (SDG)

Descriptive Statistics of Supplier-Dominated Goods (SDG)

Table 30

Descriptive Statistics of the Examined Variables

Innovation taxonomy- Supplier Dominated Goods (SDG)

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	3.5127	0.5465	2.3133	4.2845
Physical capital	187	14.3050	1.5135	11.7654	16.7764
Employment growth	170	0.0315	0.0514	-0.2709	0.1234
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of Supplier Dominated Goods (SDG)

Table 31

Correlation Matrices for Examined Variables

Innovation taxonomy- Supplier Dominated Goods (SDG)

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools**.**	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.4752	1						
Employment growth	0.3057	0.0479	1					
Human capital	0.3061	-0.293	0.1965	1				
Internet access in schools	0.1364	-0.5104	0.2028	0.4673	1			
Availability of the latest technologies	0.5857	0.1093	0.2543	0.5052	0.6302	1		
FDI technology transfer	0.1614	-0.2054	0.0067	0.3334	0.3033	0.4191	1	
Property rights	0.6097	0.0851	-0.011	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of Supplier Dominated Goods (SDG)

Table 32

Unit-Root Test (**Hadri LM**) for GDP per person employed

Innovation taxonomy- Supplier Dominated Goods (SDG)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Ho: All panels are stationary Number of panels = 17

Ha: Some panels contain unit roots Number of periods = 11

Time trend: Not included Asymptotics: T, N -> Infinity

Heteroskedasticity: Not robust sequentially

LR variance: (not used)

	Statistic	p-value
z	17.2337	$p<0.001$

Ho is rejected.

3.2.2 Results of Scale Intensive Industry (SII)

Descriptive Statistics of Scale Intensive Industry (SII)

Table 33

Descriptive Statistics of the Examined Variables

Innovation taxonomy- Scale Intensive Industry (SII)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	4.1613	0.5247	2.9905	5.0764
Physical capital	187	14.3050	1.5135	11.7654	16.7764
Employment growth	170	0.0437	0.0392	-0.1312	0.1175
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of Scale Intensive Industry (SII)

Table 34

Correlation Matrices for Examined Variables

Innovation taxonomy- Scale Intensive Industry (SII)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools**.**	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.5433	1						
Employment growth	0.1076	0.0165	1					
Human capital	0.3481	-0.293	0.1391	1				
Internet access in schools	-0.0671	-0.5104	0.211	0.4673	1			
Availability of the latest technologies	0.5425	0.1093	0.2211	0.5052	0.6302	1		
FDI technology transfer	0.2465	-0.2054	-0.0141	0.3334	0.3033	0.4191	1	
Property rights	0.6394	0.0851	-0.1358	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of Scale Intensive Industry (SII)

Table 35

Unit-Root Test (**Hadri LM**) for GDP per person employed

Innovation taxonomy- Scale Intensive Industry (SII)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Ho: All panels are stationary Number of panels = 17

Ha: Some panels contain unit roots Number of periods = 11

Time trend: Not included Asymptotics: T, N -> Infinity

Heteroskedasticity: Not robust sequentially

LR variance: (not used)

	Statistic	p-value
z	18.5501	p<0.001

Ho is rejected.

3.2.3 Results of Specialised Goods Suppliers (SGS)

Descriptive Statistics of Specialised Goods Suppliers (SGS)

Table 36

Descriptive Statistics of the Examined Variables

Innovation taxonomy- Specialised Goods Suppliers (SGS)

Dependent variable: Productivity Growth $\Delta\ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	176	5.0518	0.5026	4.0702	6.1769
Physical capital	176	14.2752	1.5552	11.7654	16.7764
Employment growth	160	0.0390	0.0927	-0.4344	0.3414
Human capital	176	3.3875	0.2866	2.6603	3.8488
Internet access in schools	176	1.6390	0.1651	1.1814	1.8893
Availability of the latest technologies	176	1.7427	0.1014	1.4394	1.8940
FDI technology transfer	176	1.5808	0.1298	1.2952	1.8615
Property rights	176	1.6484	0.1611	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of Specialised Goods Suppliers (SGS)

Table 37

Correlation Matrices for Examined Variables

Innovation taxonomy- Specialised Goods Suppliers (SGS)

Dependent variable: Productivity Growth $\Delta\ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools**.**	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.4683	1						
Employment growth	-0.1235	-0.1665	1					
Human capital	0.0552	-0.3128	-0.0015	1				
Internet access in schools	-0.096	-0.5247	0.1564	0.4632	1			
Availability of the latest technologies	0.4623	0.0942	-0.0235	0.489	0.6266	1		
FDI technology transfer	0.2742	-0.2202	-0.0106	0.3188	0.2976	0.4031	1	
Property rights	0.5701	0.0775	-0.1294	0.4923	0.3636	0.7616	0.4368	1

Source: Author's compilation (2022)

Unit root test of Specialised Goods Suppliers (SGS)

Table 38

Unit-Root Test (**Hadri LM**) for GDP per person employed

Innovation taxonomy- Specialised Goods Suppliers (SGS)

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Ho: All panels are stationary Number of panels = 17

Ha: Some panels contain unit roots Number of periods = 11

Time trend: Not included Asymptotics: T, N -> Infinity

Heteroskedasticity: Not robust sequentially

LR variance: (not used)

	Statistic	p-value
z	15.4397	p<0.001

Ho is rejected.

3.2.4 Results of Science-Based Innovator (SBI)

Descriptive Statistics of Science-Based Innovator (SBI)

Table 39

Descriptive Statistics of the Examined Variables

Innovation taxonomy- Science Based Innovator (SBI)

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	4.4096	0.7785	2.4240	6.3292
Physical capital	187	14.3050	1.5135	11.7654	16.7764
Employment growth	170	0.0495	0.0541	-0.2443	0.1951
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author’s compilation (2022)

Correlation Matrices of Science-Based Innovator (SBI)

Table 40

Correlation Matrices for Examined Variables

Innovation taxonomy- Science Based Innovator (SBI)

Dependent variable: Productivity Growth $\Delta\ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools.	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.4889	1						
Employment growth	-0.1305	-0.1219	1					
Human capital	0.2355	-0.293	0.2109	1				
Internet access in schools	-0.098	-0.5104	0.2651	0.4673	1			
Availability of the latest technologies	0.4609	0.1093	0.1534	0.5052	0.6302	1		
FDI technology transfer	0.0861	-0.2054	0.0428	0.3334	0.3033	0.4191	1	
Property rights	0.4448	0.0851	-0.0718	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of Science-Based Innovator (SBI)

Table 41

Unit-Root Test (**Hadri LM**) for GDP per person employed

Innovation taxonomy- Science Based Innovator (SBI)

Dependent variable: Productivity Growth $\Delta\ln(y)_{i,t}$

Ho: All panels are stationary Number of panels = 17

Ha: Some panels contain unit roots Number of periods = 11

Time trend: Not included Asymptotics: T, N -> Infinity

Heteroskedasticity: Not robust sequentially

LR variance: (not used)

	Statistic	p-value
z	16.2480	p<0.001

Ho is rejected.

3.2.5 Results of Supplier Dominated Services (SDS)

Descriptive Statistics of Supplier Dominated Services (SDS)

Table 42

Descriptive Statistics of the Examined Variables

Innovation taxonomy- Supplier Dominated Services (SDS)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	3.3425	0.4302	2.4913	4.2074
Physical capital	187	14.3316	1.3837	12.3138	16.7764
Employment growth	170	0.0499	0.0238	-0.0576	0.1124
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of Supplier Dominated Services (SDS)

Table 43

Correlation Matrices for Examined Variables

Innovation taxonomy- Supplier Dominated Services (SDS)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools**.**	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.1528	1						
Employment growth	0.2237	0.1189	1					
Human capital	0.3153	-0.3167	0.0617	1				
Internet access in schools	0.1115	-0.3948	0.1197	0.4673	1			
Availability of the latest technologies	0.5784	0.0942	0.2273	0.5052	0.6302	1		
FDI technology transfer	0.2066	-0.27	0.105	0.3334	0.3033	0.4191	1	
Property rights	0.6166	0.0661	0.027	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of Supplier Dominated Services (SDS)

Table 44

Unit-Root Test (**Hadri LM**) for GDP per person employed

Innovation taxonomy- Supplier Dominated Services (SDS)

Dependent variable: Productivity Growth $\Delta\ln(y)_{i,t}$

Ho: All panels are stationary		Number of panels =	17
Ha: Some panels contain unit roots		Number of periods =	11
Time trend:	Not included	Asymptotics: T, N -> Infinity	
Heteroskedasticity: Not robust			sequentially
LR variance:	(not used)		

	Statistic	p-value
z	13.5551	$p<0.001$

Ho is rejected.

3.2.6 Results of Specialised Services Suppliers (SSS)

Descriptive Statistics of Specialised Services Suppliers (SSS)

Table 45

Descriptive Statistics of the Examined Variables

Innovation taxonomy- Specialised Services Suppliers (SSS)

Dependent variable: Productivity Growth $\Delta\ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	3.9354	0.5026	2.9647	5.1443
Physical capital	187	14.3050	1.5135	11.7654	16.7764
Employment growth	170	0.0788	0.0387	-0.0552	0.2059
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author’s compilation (2022)

Correlation Matrices of Specialised Services Suppliers (SSS)

Table 46

Correlation Matrices for Examined Variables

Innovation taxonomy- Specialised Services Suppliers (SSS)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools.	Availability of the latest technologies	FDI technology transfer	Property rights
GDP per person employed	1							
Physical capital	0.3797	1						
Employment growth	-0.033	-0.2706	1					
Human capital	0.3444	-0.293	0.1775	1				
Internet access in schools	0.0873	-0.5104	0.2318	0.4673	1			
Availability of the latest technologies	0.5846	0.1093	0.0902	0.5052	0.6302	1		
FDI technology transfer	0.4039	-0.2054	0.0991	0.3334	0.3033	0.4191	1	
Property rights	0.7025	0.0851	-0.0449	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of Specialised Services Suppliers (SSS)

Table 47

Unit-Root Test (**Hadri LM**) for GDP per person employed

Innovation taxonomy- Specialised Services Suppliers (SSS)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Ho: All panels are stationary Number of panels = 17

Ha: Some panels contain unit roots Number of periods = 11

Time trend: Not included Asymptotics: T, N -> Infinity

Heteroskedasticity: Not robust sequentially

LR variance: (not used)

	Statistic	p-value
z	18.2060	p<0.001

Ho is rejected.

3.2.7 Results of Organisational Service Innovators (OSI)

Descriptive Statistics of Organisational Service Innovators (OSI)

Table 48

Descriptive Statistics of the Examined Variables

Innovation taxonomy- Organisational Service Innovators (OSI)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	5.0457	0.5139	3.7811	5.7754
Physical capital	187	14.3050	1.5135	11.7654	16.7764
Employment growth	170	0.0467	0.0294	-0.0973	0.1236
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of Organisational Service Innovators (OSI)

Table 49

Correlation Matrices for Examined Variables

Innovation taxonomy- Organisational Service Innovators (OSI)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools**.**	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.5469	1						
Employment growth	0.0673	-0.1045	1					
Human capital	0.1475	-0.293	0.1359	1				
Internet access in schools	-0.2564	-0.5104	0.2372	0.4673	1			
Availability of the latest technologies	0.3755	0.1093	0.2079	0.5052	0.6302	1		
FDI technology transfer	0.0661	-0.2054	0.1178	0.3334	0.3033	0.4191	1	
Property rights	0.4725	0.0851	-0.036	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of Organisational Service Innovators (OSI)
Table 50
Unit-Root Test (**Hadri LM**) for GDP per person employed
Innovation taxonomy- Organisational Service Innovators (OSI)
Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Ho: All panels are stationary   Number of panels = 17
Ha: Some panels contain unit roots   Number of periods = 11
Time trend: Not included   Asymptotics: T, N -> Infinity
Heteroskedasticity: Not robust   sequentially
LR variance: (not used)

	Statistic	p-value
z	19.8647	p<0.001

Ho is rejected.

3.2.8 Results of Client-Led Services (CLS)

Descriptive Statistics of Client-Led Services (CLS)
Table 51
Descriptive Statistics of the Examined Variables
Innovation taxonomy- Client-Led Services (CLS)
Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	3.9995	0.4932	3.1526	5.0422
Physical capital	187	14.3050	1.5135	11.7654	16.7764
Employment growth	170	0.0451	0.0521	-0.1549	0.4416
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of Client-Led Services (CLS)

Table 52

Correlation Matrices for Examined Variables

Innovation taxonomy- Client-Led Services (CLS)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools.	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	-0.0252	1						
Employment growth	0.2561	0.0002	1					
Human capital	0.6638	-0.293	0.2067	1				
Internet access in schools	0.3951	-0.5104	0.1214	0.4673	1			
Availability of the latest technologies	0.7083	0.1093	0.1901	0.5052	0.6302	1		
FDI technology transfer	0.4559	-0.2054	0.1624	0.3334	0.3033	0.4191	1	
Property rights	0.789	0.0851	0.1003	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of Client-Led Services (CLS)

Table 53

Unit-Root Test (**Hadri LM**) for GDP per person employed

Innovation taxonomy- Client-Led Services (CLS)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Ho: All panels are stationary Number of panels = 17

Ha: Some panels contain unit roots Number of periods = 11

Time trend: Not included Asymptotics: T, N -> Infinity

Heteroskedasticity: Not robust sequentially

LR variance: (not used)

	Statistic	p-value
z	17.0515	p<0.001

Ho is rejected.

3.2.9 Results of Non-Market Services (NMS)

Descriptive Statistics of Non-Market Services (NMS)

Table 54

Descriptive Statistics of the Examined Variables

Innovation taxonomy- Non-Market Services (NMS)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	187	3.5588	0.5603	2.3594	4.5635
Physical capital	187	14.3316	1.3837	12.3138	16.7764
Employment growth	170	0.0591	0.0172	-0.0281	0.0975
Human capital	187	3.3992	0.2824	2.6603	3.8488
Internet access in schools	187	1.6428	0.1614	1.1814	1.8893
Availability of the latest technologies	187	1.7477	0.1008	1.4394	1.8940
FDI technology transfer	187	1.5854	0.1275	1.2952	1.8615
Property rights	187	1.6528	0.1576	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of Non-Market Services (NMS)

Table 55

Correlation Matrices for Examined Variables

Innovation taxonomy- Non-Market Services (NMS)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools**.**	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.0337	1						
Employment growth	0.4014	-0.0472	1					
Human capital	0.1283	-0.3167	0.2786	1				
Internet access in schools	-0.028	-0.3948	0.1516	0.4673	1			
Availability of the latest technologies	0.2826	0.0942	0.2891	0.5052	0.6302	1		
FDI technology transfer	0.1042	-0.27	0.2563	0.3334	0.3033	0.4191	1	
Property rights	0.4257	0.0661	0.2755	0.4995	0.3644	0.7577	0.447	1

Source: Author's compilation (2022)

Unit root test of Non-Market Services (NMS)

Table 56

Unit-Root Test (**Hadri LM**) for GDP per person employed

Innovation taxonomy- Non-Market Services (NMS)

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Ho: All panels are stationary	Number of panels = 17
Ha: Some panels contain unit roots	Number of periods = 11
Time trend: Not included	Asymptotics: T, N -> Infinity sequentially
Heteroskedasticity: Not robust	
LR variance: (not used)	

	Statistic	p-value
z	19.6014	p<0.001

Ho is rejected.

3.2.10 Results of regression of innovation taxonomy of industries

Table 57 (**Model 1**)
Results of regressions – Innovation taxonomy of industries
Dependent variable: Productivity Growth $\Delta\ln(y)_{i,t}$

Independent variable	Model 1								
	SDG	SII	SGS	SBI	SDS	SSS	OSI	CLS	NMS
Constant	-1.4947	0.2315	-2.5911	0.3594	0.3554	-2.5656	-3.6948	-4.2410	-0.2532
	(-2.44)**	(1.36)	(-2.65)***	(1.70)*	(0.71)	(-5.12)***	(-6.33)***	(-7.21)***	(-0.92)
GDP per person employed	-0.0875	-0.0288	1.0302	0.3646	0.2579	0.7466	0.6475	0.4038	0.9526
	(-4.01)***	(-0.77)	(12.69)***	(15.53)***	(4.08)***	(17.35)***	(18.71)***	(3.87)***	(20.04)***
Physical capital	0.1395	0.0984	0.1413	0.3352	0.0772	0.2136	0.3776	0.4095	0.0119
	(2.67)***	(4.47)***	(2.29)**	(11.38)***	(2.74)***	(5.05)***	(6.54)***	(8.21)***	(0.55)
Employment growth	-0.2258	-0.4877	-1.0809	-0.2339	-0.6223	-0.7584	-0.4900	-0.3847	-0.0577
	(-1.85)*	(-9.34)***	(-23.22)***	(-4.42)***	(-6.22)***	(-19.04)***	(-8.81)***	(-18.03)***	(-0.58)
Human capital	0.1747	0.2047	0.1416	-0.7005	0.3140	0.1676	0.0238	0.2081	0.0790
	(2.49)**	(4.78)***	(1.51)	(-8.21)***	(7.63)***	(2.40)**	(0.26)	(2.78)***	(2.59)**
Internet access in schools	#	#	#	#	#	#	#	#	#
	#	#	#	#	#	#	#	#	#
Availability of the latest technologies	#	#	#	#	#	#	#	#	#
	#	#	#	#	#	#	#	#	#
FDI and technology transfer	#	#	#	#	#	#	#	#	#
	#	#	#	#	#	#	#	#	#
Property rights	#	#	#	#	#	#	#	#	#
	#	#	#	#	#	#	#	#	#
Observations	136	136	144	153	153	153	153	153	153
Countries	17	17	16	17	17	17	17	17	17
Instruments	20	20	13	21	49	49	49	49	28
Wald test	(4142.78)***	(1658.33)***	(1447.83)***	(2060.14)***	(150.69)***	(3194.65)***	(2595.31)***	(1061.40)***	(47088.59)***
AR(1) test	(-2.7851)***	(-1.7221)*	(-1.9631)**	(-0.9654)	(-1.2073)	(-1.6972)*	(-1.8307)*	(-1.4864)	(-1.9947)**
AR(2) test	(-1.2326)	(-1.3642)	(-2.28)**	(-1.7334)*	(-.04682)	(0.7596)	(-0.5406)	(-0.9856)	(-0.7973)
Sargan test	(14.5916)	(9.8979)	(9.6108)	(14.2264)	(12.9738)	(14.7944)	(14.2392)	(14.3701)	(14.5861)

Source: Author's compilation (2022)
Note: P<0.01 ***, P<0.05 **, P<0.1 *

Table 57 (**Model 2**)

Results of regressions – Innovation taxonomy of industries

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Independent variable	Model 2								
	SDG	SII	SGS	SBI	SDS	SSS	OSI	CLS	NMS
Constant	-1.7521	-0.8287	-4.0593	15.7253	-0.0289	-0.4442	-2.1226	-3.1536	-0.2052
	(-1.25)	(-0.94)	(-4.12)***	(3.36)***	(-0.03)	(-0.36)	(-1.73)*	(-2.70)***	(-0.55)
GDP per person employed	0.0443	0.0373	1.0639	0.0722	0.4337	0.5842	0.4060	0.4683	0.8137
	(0.45)	(-0.77)	(6.42)***	(1.03)	(4.87)***	(2.91)***	(3.54)***	(4.36)***	(7.37)***
Physical capital	0.2027	0.1565	0.2124	-0.4211	0.0011	0.1485	0.3202	0.3550	0.0694
	(2.16)**	(2.61)***	(3.16)***	(-2.40)**	(0.02)	(2.80)***	(6.19)***	(3.55)***	(2.00)**
Employment growth	1.0007	-0.3674	-1.0366	-0.1717	-0.7087	-0.7259	-0.5114	-0.3832	-0.1126
	(2.38)**	(-2.67)***	(-9.94)***	(-0.94)	(-4.45)***	(-5.81)***	(-6.28)***	(-7.33)***	(-0.21)
Human capital	0.0558	0.1659	0.1796	-0.3279	0.3755	0.2727	0.0511	0.1709	0.0260
	(0.47)	(2.93)***	(1.64)	(-1.27)	(6.79)***	(2.28)**	(0.84)	(1.74)*	(0.57)
Internet access in schools	-0.2135	0.0704	0.0018	0.9222	-0.2243	-0.2696	-0.2091	-0.1473	-0.1042
	(-4.93)***	(0.98)	(0.01)	(-3.25)***	(-1.15)	(-1.90)*	(-1.80)*	(-0.85)	(-3.21)***
Availability of the latest technologies	-0.0794	-0.1913	-0.2317	0.9495	0.7185	-0.1312	0.1965	0.3069	-0.1071
	(-0.45)	(-0.95)	(-0.91)	(1.46)	(2.86)***	(-0.67)	(1.09)	(1.01)	(-1.14)
FDI and technology transfer	0.3733	0.1676	0.1602	-0.0644	-0.0867	0.1126	0.0608	-0.3257	0.1910
	(0.96)	(2.16)**	(2.03)**	(-0.08)	(-0.63)	(0.35)	(2.44)**	(-0.53)	1.32
Property rights	0.1232	0.1528	0.2068	-2.6856	-0.0540	0.2853	0.8680	-0.1159	-0.0810
	(0.69)	(1.74)*	(2.04)**	(-5.30)***	(-0.18)	(-1.18)	(-2.29)**	(-0.51)	(-0.96)
Observations	136	136	144	153	153	153	153	153	153
Countries	17	17	16	17	17	17	17	17	17
Instruments	24	24	17	25	53	53	53	53	32
Wald test	(847.83)***	(533.79)***	(7542.44)***	(327.30)***	(141.32)***	(2130.58)***	(1546.67)***	(1950.37)***	(1876.90)***
AR(1) test	(-2.4285)**	(-2.5545)**	(-2.0834)**	(-0.6840)	(-1.5857)	(-1.1894)	(-0.2748)	(-1.5504)	(-1.6297)
AR(2) test	(-0.1904)	(-1.398)	(-2.1973)**	(-1.9826)**	(0.4790)	(0.6211)	(-0.0042)	(-0.9336)	(-0.5250)
Sargan test	(7.3867)	(5.8469)	(12.4957)	(8.5430)	(11.1044)	(11.7599)	(8.4636)	(13.0650)	(12.1443)

Source: Author's compilation (2022)

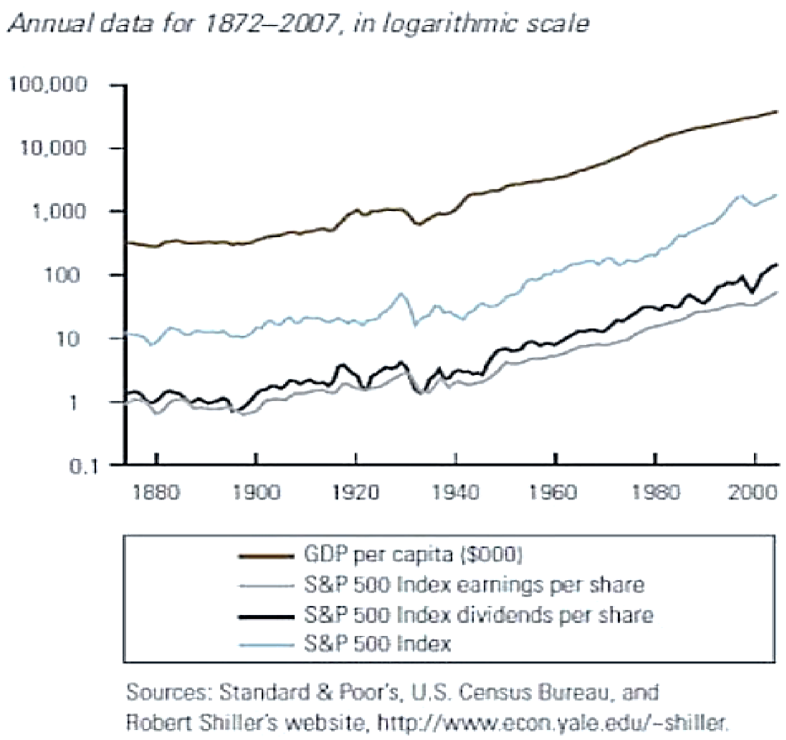
Note: P<0.01 ***, P<0.05 **, P<0.1 *

3.2.11 Evaluation and discussion of the innovation taxonomy results

Table 57 represents the regression results of the two-step GMM estimators for innovation taxonomy.

In this table, I find that there is a valid dynamic representation of the relationship between the measure of employment, human capital, and productivity growth. The impact of the GVA per capita is significant and positive z-statistics in most of the classes. As observed in the above tables, there is a highly significant relationship between investment and productivity growth in all the models. Based on the empirical research of Wilson & Smith (2019), although GDP growth does not impact investors' decision-making in the United States in the near term, it does provide a decent indicator of how the economy is performing; long-term investors should be informed of what is going on in the economy in terms of policy, technological innovation, and GDP growth potential. Strong GDP growth might contribute to long-term increases in the fundamentals of stock returns. Figure 42 shows how GDP per capita varies over the 120 years between 1880 and 2000 and how this compares to the stock market. Further, there is evidence that these factors are also correlated with trends of inflation and productivity, both key underlying drivers of GDP. Hence, it is likely that long-term GDP expectations will shape expected stock market returns and long-term strategies.

Figure 42
The US stock market and its fundamental components
and the US economy over the long run



In the Sources of the Productivity Rebound and the Manufacturing Employment Puzzle (Nordhaus, 2005), Nordhaus examines extensive industrial productivity and employment statistics dating back over 60 years, with a particular focus on the United States' productivity resurgence from 1995. Nordhaus examines the link between productivity shocks and changes in manufacturing employment using specific data on productivity and employment. Nordhaus examines the link between productivity and employment using a variety of datasets on industrial production and productivity, as well as a variety of econometric tests. He shown that faster productivity growth leads to higher rather than lower employment in manufacturing by examining the key "elasticities" between employment and productivity growth, which has been significant since 1998. Higher productivity growth may result in job losses for specific firms or industries, according to Nordhaus, who cites the drop in employment in the typewriter manufacturing industry following the introduction of the personal computer as an example.

However, the lower prices that follow from increasing productivity have enhanced demand growth and more than offset the employment-lowering effect of higher productivity. According to Nordhaus, the explanation for decreasing manufacturing employment over the previous decade does not appear to be stronger productivity growth in the United States. Instead, stronger productivity growth and more severe price drops among overseas manufacturers competing with US firms will likely be the source. Also, Capital investment can have reasonably drastic effects on productivity levels. For example, the oil industry's initial boom in the United States came partially because of the amount of capital invested in new drilling equipment. Investing in new technology companies or physical plants tends to make it easier for workers to produce goods and services more quickly due to improved productivity.

Nevertheless, when it comes to causing unemployment for workers, large investments can strain a country's labor market because they often lead to layoffs that are not compensated with high wages. This is why some believe large capital investments are good for employment but do not necessarily increase overall production levels. This fact supports the result of this research that there is a negative relationship between employment and productivity growth. As shown in the results, with a harmony of most of the literature, the effect of human capital on productivity growth is positive and significant in most of the classes. This matches the results of the scholar who has proven that labor, physical, and human capital are positively related to economic growth and that the coefficients are statistically significant (Qadri & Waheed, 2013). Nevertheless, in the SBI class of the model 1, there is a significant negative coefficient. Hence, human capital is controversially correlated with productivity growth.

Furthermore, the result shows that there is a positive influence on productivity growth when there is a one-unit increase in Internet access in schools in SII, SGS, and SBI sectors, and this relationship is negative in the other sectors. Scholars also have different points of view in this regard. Some studies have proven that Internet access in schools and economic growth are positively related in OECD countries (Devarajan et al., 1996; Eriçok & Yılancı, 2013; Psacharopoulos & Patrinos, 2018), but in many cases, these impacts could take place in long-run. In addition, Kho et al. (2011) conducted a study on the impacts of internet access in schools in Peru between 2007 and 2017, comparing schools with internet access with those that either had no access or had obtained it later. In the first 18 months, they found that schools with internet access reported only moderately higher performance of students on standardized math tests with standard deviations between 0.04 and 0.08. However, the divergence between students with and without internet access grew increasingly pronounced each subsequent year. The growing impact of school connectivity was attributed to several factors. Among these, one of the main drivers was the hiring of teachers over time who were trained in using computers and the internet and could, therefore, more effectively integrate digital tools into their teaching over time. It was found that schools were more likely to have a computer-trained teacher by 2.1 percentage points up to one year after connecting to the internet and by 9.6 percentage points up to five years later. The same results have shown a positive and negative relationship between the availability of the latest technology and productivity growth in the case of OECD countries. Some scholars have supported the positive results. For example, Caselli & Coleman (2001) focused on computer adoption in a large number of OECD countries from 1970 to 1990. They found that worker aptitude (measured as educational level), openness to manufacturing trade, and the overall investment rate in the country are among the important determinants of the level of investment in computers. As the authors point out, trade openness is significant not because computers comprise a large share of manufacturing imports; computers are usually a small fraction of total manufacturing imports. At the household level within the United States, Kennickell & Kwast (1997) also find evidence for the role of education, consumer skills, and learning in their study of the consumer adoption of electronic banking. 70% of all American households used some form of electronic banking in 1995, but only a small fraction of households used the more recent and advanced forms of electronic banking such as bill paying. The most common use of electronic banking was for making direct deposits, which is a relatively well-established and old technology, one that is widely used throughout the world, indirectly confirming the existence of a learning effect. As technology develops and improves, more people become familiar with it and comfortable using it, and this accelerates the speed of adoption.

All these findings prove the important role of technology adaptation in increasing productivity from a macroeconomic perspective. In addition, FDI and technology transfer variables positively correlated with productivity growth in most of the sectors. Fujimori & Sato (2015) examined the relationship between the level of TFP and the level of FDI in each industry. Researchers found a positive relationship between FDI & and technology transfer variables and economic growth (Lensink & Morrissey, 2001); Blomström et al., 1992; Borensztein et al., 1995; Campos & Kinoshita, 2002). Property rights positively and negatively correlated with productivity growth in different sectors. According to Mate (2014), a 1% increase in the level of patents increases (0.28%) productivity. Furthermore, trademarks are also positively correlated with productivity growth with existing significant z-statistics.

3.3 Results of R&D Intensities taxonomy of industries

3.3.1 Results of High-Technology (HT)

Descriptive Statistics of High-Technology (HT)

Table 58

Descriptive Statistics of the Examined Variables

R&D Intensities taxonomy- High-Technology (HT)

Dependent variable: Productivity Growth $\Delta\ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	162	4.6470	0.6425	3.1657	6.1601
Physical capital	165	14.5997	1.3610	12.3138	16.7764
Employment growth	147	0.0396	0.0691	-0.3847	0.3183
Human capital	165	3.3675	0.2836	2.6603	3.8488
Internet access in schools	165	1.6233	0.1602	1.1814	1.8832
Availability of the latest technologies	165	1.7436	0.1045	1.4394	1.8940
FDI technology transfer	165	1.5738	0.1294	1.2952	1.8615
Property rights	165	1.6391	0.1607	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of High-Technology (HT)

Table 59

Correlation Matrices for Examined Variables

R&D Intensities taxonomy- High-Technology (HT)

Dependent variable: Productivity Growth $\Delta\ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools.	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.4116	1						
Employment growth	-0.113	0.0518	1					
Human capital	0.5955	-0.1404	0.0619	1				
Internet access in schools	0.0775	-0.4179	0.1304	0.411	1			
Availability of the latest technologies	0.5816	0.2098	0.0425	0.5041	0.6572	1		
FDI technology transfer	0.3055	-0.1017	-0.0759	0.2902	0.2706	0.3916	1	
Property rights	0.6903	0.2579	-0.1557	0.4803	0.3488	0.7564	0.3977	1

Source: Author's compilation (2022)

Unit root test of High-Technology (HT)

Table 60

Unit-Root Test (**Hadri LM**) for GDP per person employed

R&D Intensities taxonomy- High-Technology (HT)

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Ho: All panels are stationary	Number of panels = 15
Ha: Some panels contain unit roots	Number of periods = 10
Time trend: Not included	Asymptotics: T, N -> Infinity
Heteroskedasticity: Not robust	sequentially
LR variance: (not used)	

	Statistic	p-value
z	10.6208	$p<0.001$

Ho is rejected.

3.3.2 Results of Medium-High-Technology (MHT)

Descriptive Statistics of Medium-High-Technology (MHT)

Table 61

Descriptive Statistics of the Examined Variables

R&D Intensities taxonomy- Medium-High-Technology (MHT)

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	162	4.1736	0.5868	2.4352	5.1281
Physical capital	165	14.5997	1.3610	12.3138	16.7764
Employment growth	148	0.0393	0.0619	-0.2302	0.2524
Human capital	165	3.3675	0.2836	2.6603	3.8488
Internet access in schools	165	1.6233	0.1602	1.1814	1.8832
Availability of the latest technologies	165	1.7436	0.1045	1.4394	1.8940
FDI technology transfer	165	1.5738	0.1294	1.2952	1.8615
Property rights	165	1.6391	0.1607	1.3461	1.8975

Source: Author’s compilation (2022)

Correlation Matrices of Medium-High-Technology (MHT)

Table 62

Correlation Matrices for Examined Variables

R&D Intensities taxonomy- Medium-High-Technology (MHT)

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools.	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.6016	1						
Employment growth	0.1128	-0.0018	1					
Human capital	0.4268	-0.1404	0.072	1				
Internet access in schools	0.1801	-0.4179	0.2123	0.411	1			
Availability of the latest technologies	0.6521	0.2098	0.127	0.5041	0.6572	1		
FDI technology transfer	0.1288	-0.1017	-0.0094	0.2902	0.2706	0.3916	1	
Property rights	0.6336	0.2579	-0.1677	0.4803	0.3488	0.7564	0.3977	1

Source: Author's compilation (2022)

Unit root test of Medium-High-Technology (MHT)

Table 63

Unit-Root Test (**Hadri LM**) for GDP per person employed

R&D Intensities taxonomy- Medium-High-Technology (MHT)

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Ho: All panels are stationary Number of panels = 15

Ha: Some panels contain unit roots Number of periods = 10

Time trend: Not included Asymptotics: T, N -> Infinity

Heteroskedasticity: Not robust sequentially

LR variance: (not used)

	Statistic	p-value
z	10.6776	$p<0.001$

Ho is rejected.

3.3.3 Results of Medium-Low-Technology (MLT)

Descriptive Statistics of Medium-Low-Technology (MLT)

Table 64

Descriptive Statistics of the Examined Variables

R&D Intensities taxonomy- Medium-Low-Technology (MLT)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	163	4.0617	0.4353	2.6179	4.8087
Physical capital	165	14.5997	1.3610	12.3138	16.7764
Employment growth	148	0.0323	0.0698	-0.3599	0.3297
Human capital	165	3.3675	0.2836	2.6603	3.8488
Internet access in schools	165	1.6233	0.1602	1.1814	1.8832
Availability of the latest technologies	165	1.7436	0.1045	1.4394	1.8940
FDI technology transfer	165	1.5738	0.1294	1.2952	1.8615
Property rights	165	1.6391	0.1607	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of Medium-Low-Technology (MLT)

Table 65

Correlation Matrices for Examined Variables

R&D Intensities taxonomy- Medium-Low-Technology (MLT)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools.	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.5826	1						
Employment growth	0.0636	-0.0127	1					
Human capital	0.4189	-0.1507	0.1745	1				
Internet access in schools	0.029	-0.4219	0.2226	0.4147	1			
Availability of the latest technologies	0.5373	0.2112	0.2072	0.4987	0.654	1		
FDI technology transfer	0.0758	-0.1027	0.0776	0.2902	0.271	0.3911	1	
Property rights	0.5504	0.2649	-0.0779	0.4675	0.3413	0.7556	0.395	1

Source: Author's compilation (2022)

Unit root test of Medium-Low-Technology (MLT)

Table 66

Unit-Root Test (**Hadri LM**) for GDP per person employed

R&D Intensities taxonomy- Medium-Low-Technology (MLT)

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Ho: All panels are stationary — Number of panels = 15

Ha: Some panels contain unit roots — Number of periods = 10

Time trend: Not included — Asymptotics: T, N -> Infinity sequentially

Heteroskedasticity: Not robust

LR variance: (not used)

	Statistic	p-value
z	6.8838	p<0.001

Ho is rejected.

3.3.4 Results of Low-Technology (LT)

Descriptive Statistics of Low-Technology (LT)

Table 67

Descriptive Statistics of the Examined Variables

R&D Intensities taxonomy- Low-Technology (LT)

Dependent variable: Productivity Growth $\Delta \ln(y)_{i,t}$

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per person employed	162	3.8413	0.5906	2.6449	4.9800
Physical capital	165	14.5997	1.3610	12.3138	16.7764
Employment growth	148	0.0324	0.0407	-0.1844	0.1473
Human capital	165	3.3675	0.2836	2.6603	3.8488
Internet access in schools	165	1.6233	0.1602	1.1814	1.8832
Availability of the latest technologies	165	1.7436	0.1045	1.4394	1.8940
FDI technology transfer	165	1.5738	0.1294	1.2952	1.8615
Property rights	165	1.6391	0.1607	1.3461	1.8975

Source: Author's compilation (2022)

Correlation Matrices of Low-Technology (LT)

Table 68

Correlation Matrices for Examined Variables

R&D Intensities taxonomy- Low-Technology (LT)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Variable	GDP per person employed	Capital stock	Employment growth	Human Capital	Internet access in schools.	Availability of the latest technologies	FDI technolog y transfer	Property rights
GDP per person employed	1							
Physical capital	0.4872	1						
Employment growth	0.1868	0.1677	1					
Human capital	0.5427	-0.1404	0.1874	1				
Internet access in schools	0.0629	-0.4179	0.1408	0.411	1			
Availability of the latest technologies	0.5441	0.2098	0.2404	0.5041	0.6572	1		
FDI technology transfer	0.2803	-0.1017	0.0113	0.2902	0.2706	0.3916	1	
Property rights	0.6943	0.2579	-0.0926	0.4803	0.3488	0.7564	0.3977	1

Source: Author's compilation (2022)

Unit root test of Low-Technology (LT)

Table 69

Unit-Root Test (**Hadri LM**) for GDP per person employed

R&D Intensities taxonomy- Low-Technology (LT)

Dependent variable: Productivity Growth $\Delta ln(y)_{i,t}$

Ho: All panels are stationary		Number of panels = 15
Ha: Some panels contain unit roots		Number of periods = 10
Time trend: Not included		Asymptotics: T, N -> Infinity
Heteroskedasticity: Not robust		sequentially
LR variance: (not used)		
	Statistic	p-value
z	17.3472	p<0.001

Ho is rejected.

3.3.5 Results of regression of R&D intensities taxonomy

Table 70

Results of regressions - R&D intensities taxonomy of industries

Dependent variable: productivity growth Dln(y)i,t-1

Independent variable	Model 1				Model 2			
	HT	MHT	MLT	LT	HT	MHT	MLT	LT
Constant	-2.3072	-6.2515	-5.1405	-1.3416	4.3347	-2.2733	1.0501	1.7469
	(-1.61)	(-5.39)***	-4.86	(-1.89)	(2.37)**	(-0.89)	(1.19)	(1.06)
GDP per person employed	-0.1101	0.5546	-0.0833	0.4307	-0.3011	0.4716	0.0201	0.4168
	(-1.16)	(11.14)***	-0.73	(3.70)	(-2.31)**	(3.64)***	(0.12)	(2.21)**
Physical capital	0.3994	0.5414	0.5018	0.1820	0.2591	0.1604	0.1158	0.0454
	(3.06)***	(5.88)***	5.13	(2.91)	(1.57)	(0.93)	(1.64)	(0.57)
Employment growth	-0.4661	-0.0118	-0.3570	-0.0059	-0.3494	0.0065	-0.4834	-0.0867
	(-5.08)***	(-0.17)	-2.15	(-0.05)	(-5.58)***	(0.02)	(-2.59)***	(-0.74)
Human capital	0.4962	0.0503	0.6514	0.2641	0.2396	0.4523	0.7213	0.3134
	(3.17)***	(0.51)	6.70	(2.45)	(0.94)	(1.65)*	(3.57)***	(2.46)**
Internet access in schools	#	#	#	#	-0.0694	0.6596	0.0240	-0.0673
	#	#	#	#	(-0.24)	(4.37)***	(0.09)	(-0.62)
Availability of the latest technologies	#	#	#	#	0.0871	0.1456	-0.2801	-0.2054
	#	#	#	#	(0.13)	(0.48)	(-0.65)	(-1.07)
FDI and technology transfer	#	#	#	#	-1.0869	-0.6367	0.4483	-0.1128
	#	#	#	#	(-1.64)	(-1.88)*	(1.15)	(-0.40)
Property rights	#	#	#	#	-0.7671	0.1812	-0.9155	-0.3717
	#	#	#	#	(-1.81)*	(0.41)	(-5.39)***	(-1.01)
Observations	132	132	133	132	132	132	133	132
Countries	15	15	15	15	15	15	15	15
Instruments	13	49	13	49	17	53	17	53
Wald test	(428.66)***	(808.19)***	(293.51)***	(937.79)***	(909.42)***	(500.70)***	(656.88)***	(688.20)***
AR(1) test	(0.8650)	(-1.2265)	(0.1655)	(-2.2757)**	(0.2229)	(-1.0593)	(0.5785)	(-1.9075)*
AR(2) test	(0.0262)	(-0.9688)	(-1.1954)	(-1.539)	(0.7404)	(-0.6974)	(1.1568)	(-1.3452)
Sargan test	(11.9163)	(13.7593)	(11.2707)	(12.2386)	(3.1740)	(12.3896)	(8.8255)	(8.6222)

Source: Author's compilation (2022)

Note: P<0.01 ***, P<0.05 **, P<0.1 *

3.3.6 Evaluation and discussion of the R&D intensities taxonomy

Table 70 includes the R&D intensities taxonomy regression results.

In this table, productivity growth has a strong positive relationship with investment in all classes and this relationship is highly significant in some sectors. This result is similar to the Khan & Reinhart (1990) findings. They estimated the effect of investment on economic growth in 24 countries in the private and public sectors. In the results of both, they found that the coefficient of private investment is positive and significantly different from zero at the 1% level. However, in my result, as the estimated coefficient is significantly different from zero at the 5% level, investment in R&D-intensive sectors directly affects economic growth.

Employment is negatively correlated to productivity growth in all sectors. This result matches the scientific work of scholars such as Rahman Khan (2007), who found that the employment elasticity of GDP growth is 0.7. A literature review by Basnett & Sen (2013) identifies an extensive body of evidence that suggests that growth in manufacturing and services has happened when there is a particularly relationship between employment and economic growth. The impact of employment on GDP growth in agriculture is found to be limited overall, while value-added growth in agriculture has a relatively large impact on employment. The body of evidence for textiles was small, but the studies suggest that growth positively contributed to job creation. For agri-business/food processing, the authors find a positive impact of growth on employment.

In addition, human capital is positively associated with productivity growth in all the sectors and at a significant level in most of the classes. According to the neoclassical growth theories such as Mankiw G. et al. (1992), there is a highly significant impact on and positive relationship between human capital and productivity growth in all the models. Much of the motivation for human capital policies is the possibility of providing economic growth that will raise income levels in these countries, based on (Hanushek, 2013). In this case, Qadri & Waheed (2013) examined the theoretical relationship between human capital and economic growth in a cross-section of 106 countries. They found that human capital is positively related to economic growth. However, the rate of return on human capital is higher in low-income countries than the overall returns of human capital across the world. The results obtained from the full sample model and the model having low-income countries are robust when including the other growth-related variables.

Regarding internet access in schools, HT and LT are positively correlated to productivity growth, and MHT and MLT are negative. One class has a highly significant impact on productivity growth (MHT). According to Hanushek (2013), the rapid expansion of new digital learning technologies– both as blended learning with teachers and technology and as standalone approaches suggest that many of the past decisions on access and quality might rapidly lead to being more productive. Also, the Economist Intelligence Unit (EIU) -funded by Ericsson in support of UNICEF- mentioned that connecting schools to the internet can result in up to 20% GDP growth with a limited broadband connection. Higher internet penetration provides an opportunity to develop the skills of teachers in a cost-effective manner, which is particularly crucial when there is a shortage of qualified teachers. As access to education worldwide grows, there is a risk that the teaching profession could become unmanageable with growing class sizes. In this context, digital technologies can also support teachers by providing them with additional tools and, through blended learning approaches, freeing time for them to focus on teaching rather than on administration. Furthermore, internet access enables teachers to focus attention where needed by providing real-time information on student performance.

Moreover, in the case of the latest technology, it is positively and negatively correlated to productivity. Bayarçelik & Taşel (2012) examine the relationship between researchers employed in R&D departments, R&D expenditures, patents as innovation indicators, and Gross Domestic Product (GDP) as economic growth. They used a panel regression model to investigate these relations for chemical firms listed on the Istanbul Stock Exchange (ISE) between 1998 and 2010. The results show a strong correlation between the number of R&D employees and GDP. However, there is a weak correlation between R&D investments and GDP.

Furthermore, the FDI and technology transfer variable has not had a significant impact on productivity growth and its negatively correlted with. Borensztein et al. (1995) proved a statistically significant negative relationship between the linear term of FDI and economic growth. However, based on some of the literature, the relationship should be positive, where FDI and technology transfer enhance productivity. In this case, Zhang K. (2001) found that FDI and economic growth have a favorable association. Zhang used data from 11 countries in East Asia and Latin America to investigate the causality between FDI and economic growth. Other scholars such as Bengoa & Sanchez-Robles (2003) explore the interplay between economic freedom, foreign direct investment, and economic growth using panel data analysis for a sample of 18 Latin American countries from 1970 to 1999. They found that economic freedom in the host country is a positive determinant of FDI inflows.

Regarding property rights, the result same as the FDI & technology transfer, shows a negative relationship between Property rights and productivity growth in all sectors. In the meantime, this relationship is significant in HT and MLT sectors. However, based on the literature, the relationship is positive most of the time. According to Novotny (2013), stronger patent rights help secure greater technology transfer in industries, leading to economic growth.

6 CONCLUSIONS

This study contributed to literature combined with a few extents. First, this research established a strong relationship between the effect of ICT as the internet in schools, availability of the latest technology, FDI and technology transfer, and institutions as the property right on productivity growth in OECD countries in the case of the sectoral approach.

The result demonstrated a negative relationship between internet access in schools and productivity growth in Skill taxonomy. This relationship in Innovation taxonomy as well as R&D intensities taxonomy is partially positive but not significant in most of the classes.

Also, the results proven that in Skill taxonomy, the relationship between the availability of the latest technology and productivity growth is positive in all sectors and significant in some them. This relationship in the innovation taxonomy is partially positive and significant, and in the R&D intensities taxonomy partially positive but not significant.

Regarding the relationship between FDI & technology transfer and economic growth, the results show that this relationship in the skill taxonomy is partially positive and significant, and the same results are in the innovation taxonomy. It is mostly negative and not significant in the taxonomy of R&D intensities.

Finally, Property right is not significant and negative associated with productivity growth in the Skill taxonomy; it is partially positive and significant related to economic growth in the Innovation taxonomy, in the case of the R&D intensities taxonomy, this relationship is partially positive and not significant.

The finding of this study partially confirmed previous research on internet access in schools and productivity growth (Devarajan et al., 1996; Eriçok & Yılancı, 2013; Psacharopoulos & Patrinos, 2018). Also, the result related to the correlation between the availability of the latest technology and productivity growth is in harmony with Caselli & Coleman (2001). The result of this study is comparable to the results from Lensink & Morrissey(2001), Borensztein et al., 1995; Campos & Kinoshita (2002) as well as Mate (2014); Sattar & Mahmood (2011), who investigated the FDI & technology transfer, as well as the property right, is partially positive associated with productivity growth.

6.1 Recommendation and Policy Implications

This research recommends that decision-makers and governments use the Internet in schools in OECD countries for a specific policy. The nature of the internet can be easily accessed, and the information can be easily disseminated. The use of this education technology has diversified the opportunities for individuals to learn, companies to grow, and students, in general, to facilitate their studies. It is common for schools, colleges, and universities to implement internet-based education programs designed specifically for students.

Internet-based educational programs are becoming very popular today as they deal with their advantages in facilitating student engagement and providing educational materials at a reasonable price level where they may not be traditionally offered. Therefore, internet use in educational institutions has been considered remarkably successful compared to traditional school learning methods.

Using the Internet in schools benefits the national economy and gross domestic production. Preventing the global economy from stagnating, broadening access to knowledge and information, and improving the educational opportunities for rural and remote residents are some of the reasons why there is a need to use e-learning.

After reviewing several studies conducted on internet use in schools in OECD countries, this research shows a general trend toward using information technology in educational institutions. In general, using the internet in schools has positive results on student learning.

Research findings indicated that using the Internet in schools may give positive results in furthering learning towards improved academic results, better student engagement, enhanced retention in school, and overall school performance. The findings also showed a need to promote Internet-based Education in OECD countries because it can promote social and economic growth.

Based on this research review, it can be concluded that there should be an increase in efforts to implement the Internet in schools to improve learning outcomes and enhance student engagement in school.

These strategies can include, but are not limited to, continuous and adequate training for teachers, facilities such as broadband internet access, laptop computers for students, and adequate computer equipment or ICT for schools.

In addition, This paper recommends that decision-makers invest in expanding the availability of the latest technologies in OECD countries.

The use of outdated technology increases costs while producing less efficient results, in turn discouraging economic development. Decision-makers must make the right investments to mitigate this trend, which will have implications for policy design and implementation.

Regarding these decisions, we must consider where opportunities lie within existing infrastructures and how we reconcile them with new challenges.

These challenges create gaps in infrastructure development and implementation, which leads to increased costs. To address these challenges and continue development, decision-makers need to be able to choose the most efficient technology and design policies that will encourage them to do so. For example, global communication systems can currently serve as a platform for addressing some of these challenges. The mobile cellular telephone infrastructure is a system designed for mobile communications with a low marginal cost of usage. The wired telephone system is another global communications platform that supports voice calling at a low cost for long distances.

The availability of the latest technologies has a positive effect on economic growth. Therefore, investment in technology development can increase economic growth for the governments and countries in OECD countries.

In the case of FDI and technology transfer, OECD countries have a complex relationship with FDI, which is why investing the per capita of a foreign investor in OECD countries is complicated. On the other hand, non-OECD countries offer attractive plans and facilities compared with OECD countries (such as low tax and customs tariffs when importing raw materials or re-exporting the goods). Foreign direct investment arises when national businesses invest in subsidiaries or branches in a foreign country. Foreign direct investment can take two forms: greenfield investments, which mean establishing new facilities, or mergers and acquisitions (M&A), which means acquiring an existing company. Investments can be either debt or equity-based but often involve both types of capital at the same time.

Property rights are the degree to which individuals or groups control specific things. If a person owns a particular object with national worth, they do not have the right to destroy it. The idea of property rights remains at the core of societies because everyone agrees that this arrangement is good for them in certain ways. However, some believe property rights are economically harmful because they incentivise people to take advantage of others instead of sharing something.

The early researchers have indicated the importance of property rights and limited government, but if we look at history, we find that the government has begun to take control over property rights.

In recent years, there has been a growing tendency for governments to create more powers to control people's private property. When taking a look at what kind of property governments are controlling. There is one particular item that can be moved from free people control to government control. The land is one kind of property that is being used to feed the planning process and expand the power of governance at a lower cost. This is where zoning laws come in since they are put in place by politicians who want their supporters to get richer and help them get re-elected. That is why we see that, sometimes, the effects of property rights in some countries are negative. The reason can be related to these rules. However, scholars proved that this relationship must be positive. Property rights have an outsized effect in the developing world, where they have been found to account for a sizable share of the difference between rich and poor nations. Ownership makes a fundamental difference in how people approach their work and interact with society. However, what is it that makes property rights so essential? This is the point that decision-makers and governments should consider and create their approach based on it.

6.2 Limitations and future direction of the study

- ✓ The main limitation of this study is the data related to independent variables for some of the countries and times selected. At the beginning of the research, I selected 17 independent variables, but because of this limitation, I had to decrease the number of variables.
- ✓ The literature of this study did not compare the results of OECD countries in some of the taxonomies' sectors.
- ✓ Due to the COVID-19 pandemic, and because my family and I were infected by the Coronavirus 2 times and had to be in hospital, I was not able to focus on this research for some months. Therefore, after recovery, I faced a big problem with lacing the time to do this study.
- ✓ This is also recommended for future studies to investigate the effect of the pandemic on the relationship between ICT as well as institutions on productivity growth in OECD countries.

6.3 Main conclusion and novel findings of the study

1. This research proposes a good model describing the effect of ICT as the internet in schools, availability of the latest technology, FDI & and technology transfer, and institutions as the property right on productivity growth.
2. Based on the literature, there is no comprehensive investigation of the influence of ICT institutions on economic growth in OECD in the three mentioned taxonomies of industries. This research covered this gap.

3. This study used analysis to prove the hypothesis. The findings show a positive relationship between internet access in schools and productivity growth. Also, the results prove that there is a positive correlation between the availability of the latest technology and productivity growth. Regarding the relationship between FDI and technology transfer and productivity growth, the results show it is the same as the result of the availability of the latest technology. Furthermore, property rights are strongly significant and positively associated with productivity growth.
4. After discussing the important role of the Internet in schools for children and teenagers studying in OECD countries, it can be argued that it positively correlates to economic growth worldwide. It can facilitate the tolls of education and enhance the level of the teacher's knowledge accordingly. Hence, it has an important influence on economic growth.
5. In the case of the availability of the latest technologies, it is evident that nowadays, all industries are directly dependent on the availability of the latest technologies. The analysis of this research proved that this relationship is positive.
6. In the case of FDI and technology transfer and economic growth relationship, most of the studies claimed there is a positive correlation between these two factors; the results of this paper show that there is a positive relationship. However, there is a point in this case: although OECD countries are developed and well-structured in government policies (such as taxes and tariffs), most investors are willing to invest their money in non-OECD countries (where developing countries offer attractive facilities). So, the decision-makers in OECD countries must consider this point.
7. Based on the findings of the previous studies, property rights are positively associated with productivity growth. However, the complicated administrative process of property rights is geared toward individuals and companies. The legal aspects of property rights take a lot of time and energy from individuals and firms.
8. The highlighted results compare the sectoral approaches such as Skill taxonomy, Innovation taxonomy, and R&D intensities taxonomy in the detailed sectors as the novel of this research.

Table 71
Results of the Hypotheses

No	Code	Hypothesis	Result
1	**H1**	**ICT is positively associated with productivity in some of the OECD countries and sectors**	**Partially Accepted**
2	H1a	Internet access in schools is positively associated with productivity in some of the OECD countries and sectors	Partially accepted
3	H1b	Availability of the latest technologies positively correlated with productivity in some of OECD countries and sectors	Accepted
4	H1c	FDI and technology transfer positively correlated with productivity in some of the OECD countries and sectors	Partially Accepted
5	**H2**	**Institutions positively influence productivity in some of the OECD countries and different sectors**	**Partially Accepted**
6	H2a	Property rights positively influence productivity in some of the OECD countries and different sectors	Partially Accepted

Source: Author's compilation based on the results of this research, 2022

7 SUMMARY

Chapter 1 describes the topics and objectives of the thesis. The main objectives are to contribute to the empirical research by investigating the effect of technology (ICT) and institutions on productivity growth in a sectoral approach in some of the OECD countries from 2008 to 2018. The research focuses directly on how the access to and usage of ICT, such as Internet access in schools, the latest technology, and foreign direct investment, as well as institutional matters such as property rights, are related to the pace of productivity change.

Chapter 2 ensures a theoretical background of the ICT indicators such as Internet access in schools, the latest technology, foreign direct investment, and institution matters such as property rights and how they affect productivity change.

Chapter 3 Describes the industry structure and its related taxonomies and the findings. illustrates Skill taxonomy, Innovation taxonomy, and R&D intensities taxonomy and their sectors.

Chapter 4 Describes the databases and the methodology applied to analyze the objectives of the thesis and respond to the hypothesis questions. The data was collected from the datasets published by the EU KLEMS, OECD STAN database, the Penn World Table, the World Bank, and the World Economic Forum. The data samples comprised OECD countries. The data were analyzed by STATA software ver. 15.0 to explore how ICT and institutions interact with productivity growth.

Chapter 5 shows the research findings, evaluation, and discussion of the results in the three categories: Skill taxonomy, Innovation taxonomy, and R&D intensities taxonomy and their sectors. For each examined category, to test the assumed model, GMM dynamic regression is applied, and the independent samples such as GDP per person employed, Capital Stock, Employment Growth, Human Capital (as the core model) and Internet access schools, Availability of the latest technologies, FDI & technology transfer and Property rights (as the assumed independent variables) and unit root test applied to be sure that the model has stationary. Finally, dynamic panel data (DPD) and Arellano-Bond Estimation are used to test the hypothesis of the research and to indicate the relationship between the variables.

Chapter 6 Describes the concluding remarks and the research and limitations. In addition, this chapter includes some recommendations for policymakers and discusses the novel findings and the main results.

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9 PUBLICATION

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Doctoral School: Károly Ihrig Doctoral School of Management and Business
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List of publications related to the dissertation

Articles, studies (3)

1. Máté, D., **Zeynvand Lorestani, V.**: The Impact Of Pandemic Downturn Exposure On Economic Growth.
   Cross-Cultural Management Journal. 23 (2), 191-198, 2021. ISSN: 2286-0452.
2. Faid, G., Tariq, M. M., Ishtiaq, A., **Zeynvand Lorestani, V.**, Meyer, D. F., Máté, D.: The nexus of e-government and increased productivity relative to income level comparsion.
   Business, Management and Education. 18 (1), 88-105, 2020. ISSN: 2029-7491.
   DOI: http://dx.doi.org/10.3846/bme.2020.12067
3. **Zeynvand Lorestani, V.**: Trends in the Internet of Things (IoT) and Influence on the Industries' Progress.
   International Journal of Engineering and Management Sciences = Műszaki és Menedzsment Tudományi Közlemények. 5 (1), 182-193, 2020. EISSN: 2498-700X.
   DOI: http://dx.doi.org/10.21791/IJEMS.2020.1.15

List of other publications

Articles, studies (5)

4. Yousuf, A., **Zeynvand Lorestani, V.**, Felföldi, J., Zatonatska, T., Kozlovskyi, S., Dluhopolskyi, O.: Companies performance management: the role of operational flexibility.
   Marketing and Management of Innovations. 1, 30-37, 2021. ISSN: 2218-4511.
   DOI: http://doi.org/10.21272/mmi.2021.1-03
5. Yousuf, A., **Zeynvand Lorestani, V.**, Oláh, J., Felföldi, J.: Does Uncertainty Moderate the Relationship between Strategic Flexibility and Companies' Performance? Evidence from Small and Medium Pharmaceutical Companies in Iran.
   Sustainability. 13 (16), 1-17, 2021. ISSN: 2071-1050.
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6. Máté, D., Erdei, E., **Zeynvand Lorestani, V.**, Popp, J., Oláh, J.: Can Internet in schools and technology adaption stimulate productivity in emerging markets? *Economics & Sociology. 13* (1), 182-196, 2020. ISSN: 2071-789X. DOI: http://dx.doi.org/10.14254/2071-789X.2020/13-1/12

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8. **Zeynvand Lorestani, V.**, Máté, D.: The Relationship Between Job Satisfaction and Employees' Loyalty: an Iranian Case Study. *Cross-Cultural Management Journal. 21* (1), 67-72, 2019. ISSN: 2286-0452.

Conference presentations (1)

9. **Zeynvand Lorestani, V.**, Máté, D.: The new trends in IoT and its role in Entrepreneurship. In: Absztraktkötet : "Kihívások és tanulságok a menedzsment területén. Fókuszban a folyamatmenedzsment - az Ipar 4.0 kihívásai" = Book of abstracts : "New Trends and Challanges in Management. Special Focus on Process Management and Industry 4.0" / [szerk. Szűcs Edit], University of Debrecen Faculty of Engineering, Debrecen, 10, 2019.

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11 LIST OF FIGURES

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