INNOVATIVE COMPETITIVENESS OF FRANCE'S SCIENCE AND RESEARCH INFRASTRUCTURE IN THE EUROPEAN UNION

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FRANSA BİLİM VE ARAŞTIRMA ALTYAPISININ YENİLİKÇİ REKABETÇİLİĞİNİN AVRUPA BİRLİĞİ'NDEKİ YERİ

Abstract

National strategies, fiscal policies, scientific talent and human capital in science and research are some of the parameters affecting the innovative performance of countries. The study aims to present France's science and research area and scientific talent in the European Union. It explains the innovative competitiveness in science and research, then compares France with the European Union countries on the basis of various indicators such as the Global Innovation Index, European Innovation Scoreboard and Eurostat. The study covers indirect measures related to human capital, scientific expenditures and knowledge production such as research investments, staff number in the science and research, collaboration with the industry and academic publishing. The research concludes that the development level of France's science and research infrastructure is not as parallel as its economic size and should be strengthened.

Keywords: European Union, France, Science, Research, Innovation.

Öz

Ulusal stratejiler, mali politikalar, bilimsel beceri ve bilim ve araştırma alanındaki beşerî sermaye ülkelerin yenilikçilik performansını etkileyen parametrelerden bazılarıdır. Bu çalışmanın amacı Fransa'nın bilim ve araştırma alanını ve bilimsel yeteneğini Avrupa Birliği içerisinde tartışmaktadır. Çalışma öncelikle bilim ve araştırmada yenilikçi rekabetçiliği tanımlamaktadır. Ardından Küresel Yenilik Endeksi, Avrupa Yenilik Skor Tahtası, Dünya Bankası ve Eurostat gibi seçilmiş göstergeler kullanılarak Fransa'nın Avrupa Birliği ülkeleri arasındaki yeri ele alınmaktadır. Çalışma, araştırma ve geliştirme yatırımları, bilim ve araştırma sektöründeki personel sayısı, sanayi iş birliği ve akademik yayın gibi bilim ve araştırma alanındaki beşerî sermaye, bilimsel harcamalar ve bilgi üretimiyle alakalı dolaylı ölçümleri tartışmaktadır. Araştırmada Fransa'nın bilim ve araştırma

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altyapısının Birlik içerisindeki ekonomik büyüklüğü ile paralel olmadığı ve bu alanın güçlendirilmesi gerektiği sonucuna ulaşmıştır.

Anahtar Kelimeler: Avrupa Birliği, Fransa, Bilim, Araştırma, Yenilik.

1. Introduction

Innovation is defined as "the successful exploitation of a new product, service, organization or a process" by European Innovation Management Academy (EIMA, 2019). It is also defined as "a new or improved product or process (or a combination) which significantly differs from the existing products or processes and has been made available for use" in Frascati Manual. Innovation has four types; product innovation, process innovation, marketing innovation and organisational innovation (OECD, 2018). The innovative capability of a country is related to its quantity and quality of its R&D activities, collaboration, creativity and capacity to turn new ideas into new goods and services (World Economic Forum, 2018).

Innovative competitiveness of countries depends on various parameters such as productivity, improved education standards, the capability of tackling corruption, openness to globalization and so on. Innovation, particularly in the information age, has a crucial role in economic growth, value creation and competition. Therefore, the most advanced economies and emerging economies try to understand what makes a country innovative. Initially, it is a widespread reality truth that a country's capability to innovate depends on the quality of its ecosystem. Secondly, only if the smart ideas turn into successful products, innovation is actualised. The third, innovation may happen everywhere, independent from settings (World Economic Forum, 2018). However, this study elaborates only issues related to science and research area as innovation is a complex process including quality of education, access to financial sources and business sophistication, and it takes place in an ecosystem with multiple factors, actors and stakeholders such as private companies, higher education institutions and entrepreneurs. Competitiveness also means the capacity of growing and productivity of employed sources. The productivity of employed sources is the value of outputs produced by labour and capital. In this regard, competitiveness depends on the quality of product and efficiency of production (Jantoń-Drozdowska & Majewska, 2013: 84).

There are huge differences and discrepancies in technical changes and transformations between late industrializing and industrialized economies, and the process of technical change can be achieved via absorbing already existing techniques (Viotti, 2002). This fixing is valid in the economies of

the European Union (EU) countries as well. That is why the EU launched the Lisbon Strategy in 2000 and The Europe 2020 Strategy in 2010 following the failures to reach the goals defined in the Lisbon Strategy.

The Europe 2020 Strategy, which was proposed in March 2010, has aimed smart, sustainable and inclusive growth and set certain thematic areas such as 'research and development (R&D)', 'employment', 'education', 'climate change and energy' and 'poverty and social exclusion'. Under these thematic areas, various key priorities such as reducing rates of school drop-outs to less than 10%, increasing the share of renewable energy consumption to 20% and increasing total R&D expenditure to 3% of Gross Domestic Product (GDP) have been targeted (European Commission, 2010a). The Strategy of the EU aimed to boost investments and ensure stable fiscal policies. Following the declaration of the Strategy, the EU countries started to set certain reforms to actualise economic growth and implemented certain policies regarding the human capital, innovation and competitiveness.

To reach the objectives of the Europe 2020 Strategy, stakeholders in science and research area have been assigned an important role underlining that these stakeholders are a key enabler of smart, sustainable and inclusive growth. This study selects France which is a founding member of the EU and the third-largest economy in the Union right now. Even though the country is one of the largest economies in the EU, its science and research infrastructure is positioned either on the average or below the average among the EU countries. Politically and partially economically, France has a pioneering and leading role in the EU, however in terms of science and research statistics, France's performance is not among the tops. Therefore, France is selected as the subject of the article. This study elaborates the comparative position of France in the EU, various parameters such as 'research and development expenditures, research and development expenditures per inhabitant in higher education sector, the number of full-time researchers per million population, new doctorate graduates per thousand population aged 25-34, share of foreign doctorate students, scientific and technical publishing per thousand population, scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country and university-research collaboration' are used.

The study concludes that it is necessary for France to make more investment in its science and research area as its infrastructure and capability are not sufficient enough compared to the other EU countries.

2. Methodology

Innovative competitiveness of a country means its capability and capacity of competing globally. This study elaborates the competitiveness capability of France's science and research area in the EU via varied indicators and methodologies.

In terms of the economy, the capacity to produce and sell products in local or global market with increasing income can be defined as competitiveness (Sachwald, 1994). At a national level, determinants of a country's competitiveness can be presented in Michael E. Porter's model of 'The Diamond of National Advantage'. According to Porter's model; national prosperity isn't inherited but created, the competitiveness of a nation depends on its industry's capacity to innovate and upgrade, and competitiveness is driven and sustained by innovation. Porter argues that the competitiveness of a country depends on the competitiveness of its firms and categorizes this diamond into four major components. The determinants Porter suggests are 'factor conditions', 'demand conditions', 'related and supporting industries' and 'firm strategy, structure and rivalry'.

> - Factor conditions; factors of production such as land, natural resources, capital and land determine the flow of trade, a country may export these possessions but these are not the only source of competitiveness. The most important thing for a nation is the ability to create, upgrade its scientific base and deploys its skilled labour.
> - Demand conditions; internal market demands products or services from the firms. Firms surviving in a competitive local market can get a competitive edge.
> - Related and supporting industries; this condition is about the competitiveness of all related industries related to the firm.
> - Firm strategy, structure and rivalry; this condition means the way how the companies are created, organized and managed (Porter, 1990: 73-89).

With these four dimensions, Porter stresses the determinants of national advantage and competitiveness and underlines the critical responsibility of government in the creation of national environment elements such as education systems, basic national infrastructure and research area. Porter highlights that effectiveness of education and research efforts of the universities create a competitive advantage for nations (Porter, 1990).

Enterprises with a high-level of competitiveness skills have key roles role in a country's competitiveness and contribute to the country's economic development, however, nations do not only depend on products and

services. A nation's ability to develop an outstanding educational system and improve their employment skills through training and research is crucial for its competitiveness (Ciocanel & Pavelescu, 2015: 728-737). The EU, in this context, has taken the responsibility of cooperation and coordination among the Member States and the Associated States in order to play a key role in responding to the needs of businesses and citizens (European Research Area, 2019) through providing strong research and science infrastructure.

Innovative competitiveness of a country's science and research area are measured by various methods. Two of the most popular methodologies are the Global Innovation Index (GII) and the European Innovation Scoreboard (EIS). These two methodologies have been chosen in this study because of their outstanding impacts in the literature and availability of international statistics in comparison. GII divides its measurement into 7 categories such as 'institutions, human capital and research, infrastructure, market sophistication, business sophistication, knowledge and technology outputs and creative outputs' and 80 sub-categories such as 'ease of getting credit, high-tech imports, foreign direct investment, logistics performance and pupil-teacher ratio etc., collecting data from more than 30 sources. To assess the innovative performance and competitiveness of science and research area of France, three sub-categories (researchers per million population, scientific/technical publications and university-industry research collaboration) are selected.

Another measurement used in the study is EIS which is implemented by the EU. EIS divides its measurement into 4 main categories (framework conditions, investments, innovation activities and impacts), 10 sub-categories (human capital, research systems, innovation-friendly environment, finance and support, corporate investments, innovators, linkages, intellectual assets, employment impacts and sales). This study makes use of sub-categories related to the concept of science and research area such as attractive research systems and its parameters (international scientific co-publications, top 10% most cited publications and foreign doctorate students), human resources (new PhD graduates), and finance and support (R&D expenditures). Additionally, Eurostat, World Bank, World Economic Forum and Regional Innovation Scoreboard (RIS) data and statistics on higher education and research systems are integrated into the study.

Measurement of innovative competitiveness involves various sophisticated methods; however, the frame of this study is restricted to the parameters related to science and research concept, which will explain key factors of innovative competitiveness in science and research in France and the EU.

It must be noted that there are limitations of each indicator employed. The indicators have been selected to assess the competitiveness of innovation in terms of human capital and expenditures in science and research discipline.

3. The European Union's Innovative Environment

The major objective of innovation has always been economic growth and competitiveness. However, in the EU's discourse, these objectives are combined with "social cohesion and equality". The EU has seen innovation as a way not only to create economic wealth but also to solve crucial problems related to pollution, energy, poverty and urbanism (Lundvall & Borrás, 2005). Considering the European sensibility, the EU's target on science and research essentially based on the idea of building an eco-system at European level through diffusing knowledge, sharing experiences and borrowing policies as quite a heterogenic environment exists in science and research area of the EU (Güner, 2019: 375).

The European Research Area (ERA) which was founded after the Lisbon Summit in 2000 has been the catalyst of knowledge generation, production and diffusion in the EU. The main target of the ERA is to coordinate and use Europe's scientific and technologic resources at European level. The EU's attempt and willpower produce considerable outcomes to increase the competitiveness of the European region with the rest of the world. With the integration of the ERA, a unified research area circulating researchers, knowledge and technology freely within the Union was enabled and this area strengthened its scientific and technologic capability against grand challenges (Akçomak, Erdil, & Çetinkaya, 2017).

With the EIS, the European Commission (EC) evaluates the innovation performances of the EU member countries. According to the EIS 2018; Sweden is the most successful country among the European countries, Denmark and Finland follow Sweden. Considering the innovation performances, the countries are categorized into four different types; Innovation Leaders, Strong Innovators, Moderate Innovators and Modest Innovators. According to the scoreboard, Innovation Leaders are Sweden, Denmark, Finland, the Netherlands, the United Kingdom and Luxembourg. Performances of these countries are above the EU average. Strong innovator countries are Germany, Belgium, Ireland, Austria, France and Slovenia. Moderate innovators are Czech Republic, Portugal, Malta, Spain, Estonia, Cyprus, Italy, Lithuania, Serbia, Hungary, Greece, Slovakia, Turkey, Latvia, Poland and Croatia. Modest innovators are Bulgaria, North Macedonia and Romania with lower performance than EU average.

4. Data and Materials

4.1. France's Science and Research Area

With its around 65 millions of population, French citizens constitute 12% of the EU's total population. As the third-largest economy in the EU, France has a good higher education, science and research system in the EU and according to international comparisons, higher education in France is mainly public-funded, and private funding in universities is weak (Duru-Bellat, 2015). GDP per capita is around $40,000 in the country and 10-year average annual GDP growth is around 0.7%. France's innovation capability is 76.1% and business dynamism is 69.4 out of 100. The country has a good-level of market size with the ratio of 81.5 out of 100, also has a well-developed infrastructure with 90.1 out of 100 and macroeconomic stability with 99.9 out of 100, while Information and Communication Technologies (ICT) adoption is 71.1% (World Economic Forum, 2018). France is also a strong innovator according to RIS 2017 (European Commission, 2017). The flexibility of entrepreneurs and ease of starting a business also contribute to the measurement of innovative capability of a country. According to the GII, France is the 8th country in the EU, following Ireland, Estonia, Sweden, the United Kingdom (UK), Belgium, the Netherlands and Latvia (Global Innovation Index, 2019). France's employment share in High and Medium high-tech products is 36.1 while the average share of the EU is 37.2 and share of employment in knowledge-intensive services is 37.1 while the average share of the EU is 35.0. Additionally, the number of top R&D spending enterprises per 10 million population is 17.1 while the same indicator is 19.7 in the EU average (European Commission, 2018a).

Picture 1: Regional Innovativeness in France
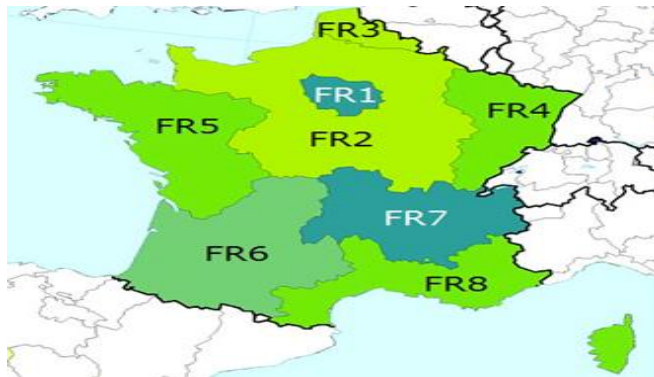
Source: (European Commission, 2017).

According to RIS 2018, France is a strong innovator as a country and includes nine NUTS 1 regions. The regions are; Île de France (FR1), Bassin Parisien (FR2), Nord - Pas-de-Calais (FR3), Est (FR4), Quest (FR5), Sud-Quest (FR6), Centre-Est (FR7), Méditerranée (FR8) and French Overseas Departments (FR9). FR1 and FR7 are Innovation Leader. FR2, FR3, FR4, FR5, FR6 and FR8 are Strong Innovators. The picture indicates that France has a homogenic innovation environment. The regions' innovative performances are close to each other in the country.

4.2.   Research and Development Expenditures

R&D activities are vital in the creation and dissemination process of new knowledge, new products, technologies and services and considered as a prerequisite for competitive economic performance. In this context, the productivity of R&D is a key indicator of knowledge production. The productivity of R&D activities is remarkably related to R&D expenditures as a percentage of GDP of a country or a region.

According to the Frascati Manual, R&D expenditure represents the amount of money which is spent on R&D activities such as labour costs of R&D staff, purchase of materials and supplies, services to support R&D activities, patenting and licensing expenses, the lease of capital goods and funding etc (OECD, 2015).

To make the EU the most competitive, dynamic and knowledge economy and to provide more sustainable economic growth with more job facilities and social cohesion, the EU set out 'the Lisbon Strategy' in 2000. The strategy document set various targets to be carried out until 2010. However, the Council of the European Union had to revise the content of the strategy because of proven deceiving in 2005. Revised Lisbon Strategy defined priority areas such as knowledge production and innovation, employment opportunities, economic growth, climate change and energy policy (Ivan-Ungureanu & Marcu, 2006: 74-76). The most important target related to innovation in the Lisbon Strategy is to increase R&D spending 3% of GDP by 2010. However, when the year 2010 came, only two of the member countries; Sweden and Finland could reach the R&D target. These two countries had already spent more than 3% of their GDP in R&D investments in 2000 (European Commission, 2010b). In respect of R&D targets, it can be inferred that the Lisbon Strategy was a huge failure.

Failure to reach the Lisbon targets made the EU prepare a brand-new strategy document. 2010 was the year that the EU declared Europe 2020 Strategy and set various targets aimed to be reached until 2020. R&D target of Europe 2020 Strategy was as the same as the Lisbon Strategy, so, the EU set the goal of allocating 3% of its GDP for R&D activities once again. In

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this respect, the EU aimed to encourage private and public sectors to increase their R&D spending as a part of Europe 2020 because R&D not only contributes to competitiveness of a country in global economy but also feeds various sectors and disciplines such as innovation, education, employment, industry and trade (Bednar & Halásková, 2018: 212). Below, the EU member and candidate countries are ranked based on their R&D expenditure as a percentage of their GDP.

Figure 1: Research and Development Expenditure as a Percentage of GDP in 2017 (% of GDP)
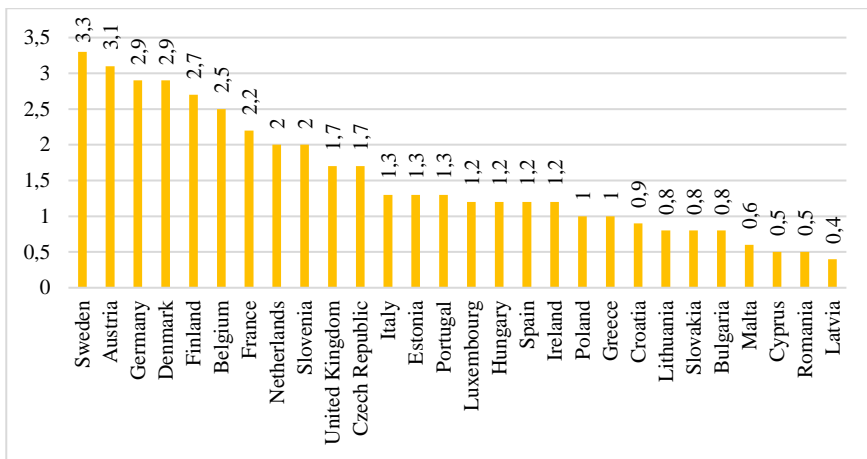
Source: (Global Innovation Index, 2019)**.**

Figure 1 compares the EU member countries and candidate countries in terms of percentage of R&D expenditures in their GDPs. Considering the Europe 2020 targets, only Sweden and Austria could reach the targets in 2018. Germany and Denmark are very close to reaching the target. Finland, which had already reached the target in 2010 decreased its R&D expenditures and regressed at the 5th row. France ranks 7th in the list with its 2,2% of R&D expenditure in 2018. As founding members of the EU, Italy ranks 12th and Luxembourg ranks 15th in the figure. The EU countries with the lowest R&D expenditures are Latvia, Romania, Cyprus, Malta and Bulgaria. The expenditure of Sweden, the 1st in the list, is 8 times more than Latvia which is positioned at the end of the list. It seems that there is a low possibility of catching the Europe 2020 targets in average R&D expenditures.

Figure 2: France's R&D Expenditure (Percentage in GDP)
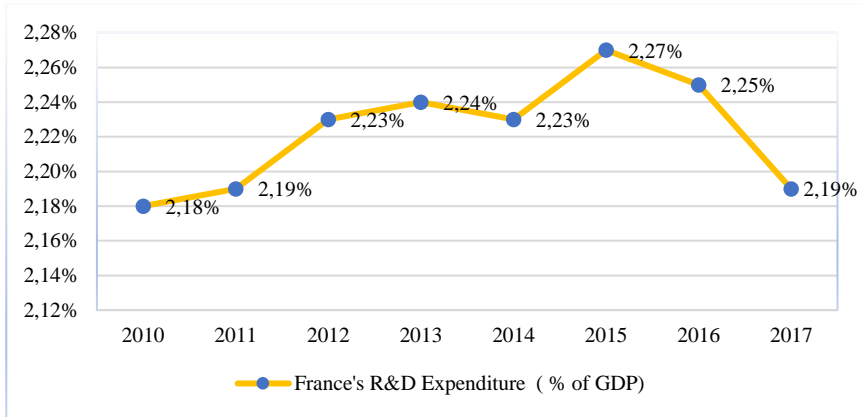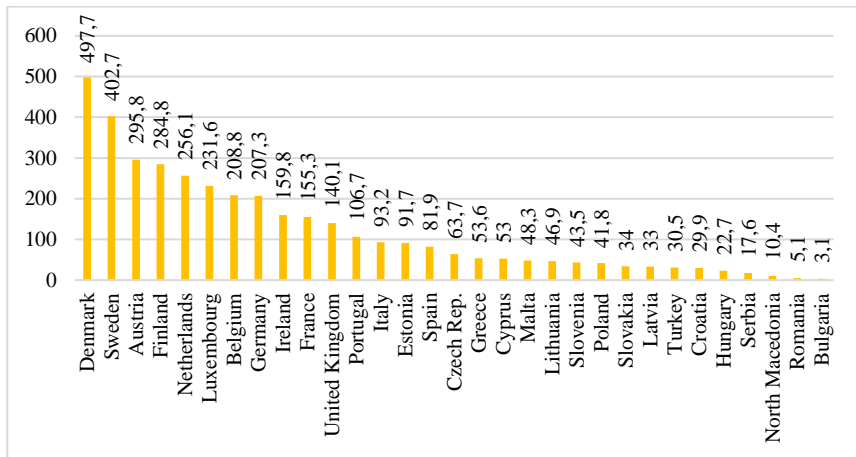

Source: (Eurostat, 2019).

The graph above shows the percentage of French government's R&D expenditure in its GDP. As seen in the graph, there is a positive trend from 2010 to 2016. However, a decrease with 0,06 point is seen from 2016 to 2017. Although the share of French government's R&D expenditure in GDP seems to be increased when it is compared to 2010, there is a clear decrease when the data of the last 5 years is considered. France spent around 2,23% of its GDP on R&D in 2012, however it decreased the proportion then. In conclusion, percentage of R&D expenditure in 2017 has been as the same as the percentage of expenditure in 2011.

R&D activities are conducted in four sectors. These sectors are; business sector, government (public), higher education (HES) and private non-profit sector. The figure above illustrates the percentage of distribution of total R&D expenditure in these four sectors in the EU.

With €196.6 billion R&D spending in Europe, the business enterprise sector which is the biggest investor in R&D is accounted for 64,9% of total R&D spending in the EU. The second-biggest investor in R&D in the EU is the HES. Government sector ranks the 3rd with 11,2% (€33,9 billion). Government sector, with its modest contribution, possesses an important role in terms of providing social and environmental projects such as quality of life, health, defence and environment. Thus, government sector contributes to long-time productivity of economic growth. Additionally, the private non-profit sector has a small role in R&D expenditure. With less the 1% of R&D expenditure, private institutions which do not seek profit allocate budget for R&D activities, as well (Eurostat, 2018).

To be able to meet the conditions of a competitive economy, not only sufficient R&D expenditures but also a strong higher education system is needed. Allocation of sufficient budget for higher education -particularly for research and development activities- plays an important role in the competition in HES. The figure below indicates the R&D spending of EU countries per inhabitant in HES. In this context, the result of the data is counted as R&D expenditure and R&D staff broken down in HES.

Figure 3: R&D Expenditure per inhabitant in HES (Euro per inhabitant)

Source: (Eurostat, 2019).

According to the figure, Denmark retains its first place in R&D expenditure per inhabitant in HES. Sweden maintains its 2nd rank and the third position was reached by Austria, Finland is the fourth and the Netherlands is the fifth. France ranks as the tenth country in R&D expenditure per inhabitant in HES. The last five countries with the lowest expenditure are Bulgaria, Romania Hungary, Croatia and Latvia. As indicated in the figure, huge gaps and discrepancies exist among the countries. France, on the other hand, retains its position on the average among the EU countries.

4.3. Scientific Talent and Academic Publishing

4.3.1. Human Capital

As the world is moving towards a knowledge economy, there is a consensus that intellectual capital, in particular, human capital is strategic in the knowledge-based economic era (Yusliza & Hazman, 2008: 178-183). In this term, wherein competitiveness is highly crucial, countries' innovative capability has more dependency on intellectual capital than fixed assets (Cabello-Medina, Lopez-Cabrales, & Valle-Cabrera, 2011).

Today, human capital is considered as an intangible asset for the innovation process and a valuable key for knowledge production, competency (Soleh, 2014) and innovation capability. Research activities' level and standards are key determinants of the innovation capacity of the nations. In particular, the success of innovation projects is essentially dependent on the scope of the network, strong human resources, mobility of researchers and doctoral training (Dutta, Lanvin, & Wunsch-Vincent, 2018).

Highly-skilled human capital is prerequisite for the development of innovation capacity and competitiveness. The Figure 4 compares the EU countries' number of researchers per million population (full-time equivalence.) Researchers in R&D are the individuals who work in the creation of new knowledge, products, processes or methods and the management of the projects concerned (OECD, 2015).

Permanent researchers have two positions; either as a lecturer or a professor teaching or doing research at a university or as a full-time researcher at a private or public institute (Carayol, 2007: 119-138).

The definition of R&D staff or researcher is established according to the OECD's Frascati Guideline. R&D staff or researcher is the direct service provider in the research and development sector, including managers, administrators and office workers. Those who provide needs such as eating, drinking and security and who contribute to the process indirectly are not defined as R&D personnel and are not included in the statistics (OECD, 2015). Indicators such as "the number of full-time researchers, doctorate graduates and foreign doctorate students" contribute to measuring of human capital dimension of R&D activities.

Figure 4: The Number of Full-time Researchers Per Million Population
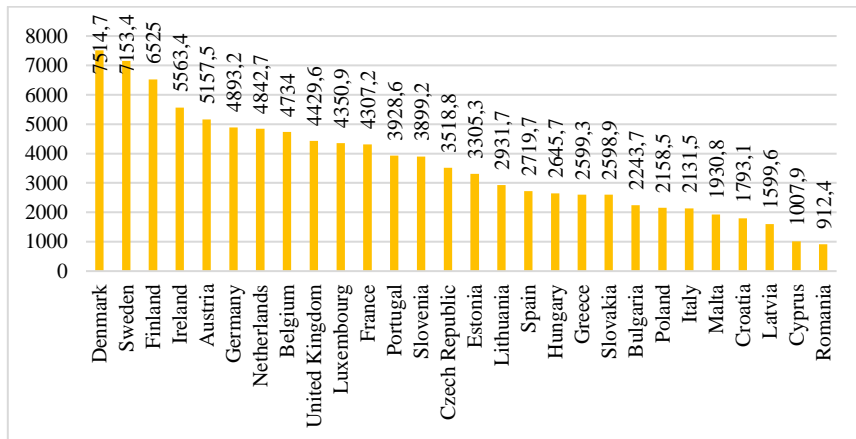
**Source:** (Global Innovation Index, 2019).

When the data about the countries are compared, a heterogenic image is shown up. The first country (Denmark) possesses 8 times more full-time researchers than the last country in the figure. Denmark, Sweden and Finland rank in the top 3 in the number of full-time researchers as shown by Figure 3. Romania, Cyprus and Latvia rank with the lowest position. France positions itself on the 11th in the list with around 4307 full-time researchers per million population, having a huge gap compared to Denmark and Sweden.

To avoid a potential skills gap and increase knowledge-intensive activities, the EU countries need a sufficient number of postgraduates. For industries, PhD graduates have an important role as they develop research projects and programs, develop innovative solutions against industrial problems and challenges, increase business performance and produce commercial outcomes.

As the researchers with graduate degree possess specialised research skills, critical understanding of scientific areas and transferrable skills, they can successfully be instrumentalised against future challenges in the sector. Their efforts can easily be transformed into successful projects and effective partnership between research centres/universities and the industry.

Figure hereinbelow indicates the number of new PhD graduates per 1000 population between 25 and 34. According to the figure, no other country in the EU has more PhD graduates (per 1000 population) than Slovenia. Denmark follows Slovenia and The UK ranks as the 3rd country in the EU. Positioned under the EU average, France ranks as the 14th country in the EU, having fewer PhD graduates than Austria, Portugal, Belgium, Slovakia and The Netherlands. Countries with the lowest number of PhD graduates are Poland, Cyprus and Malta. Slovenia, the top country, has 7 times more graduates than Poland which is located at the end of the list. France is one of the largest economies in the EU and its size is nearly close to the UK. However, the UK ranks as the 3rd and France ranks as the 14th in the list.

**Figure 5:** New Doctorate Graduates per thousand population aged 25-34
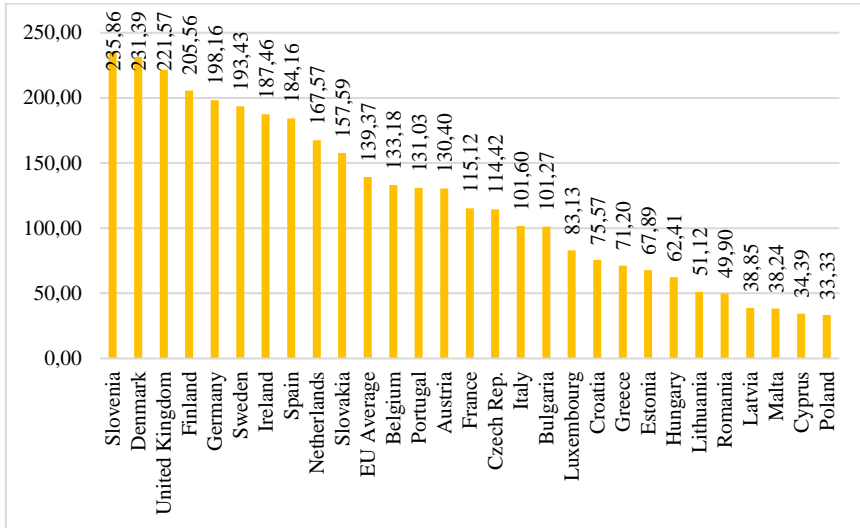
Source: (European Innovation Scoreboard, 2018).

Universities collaborate with the industry via their graduate research students as this collaboration builds workforce capability, enhance innovation and provide a career for students. Via using their knowledge and scientific capabilities, graduate students develop their innovative ideas and solve the problems in the industry. In this regard, the number of doctorate graduates and mobility of foreign doctorate students are important factors affecting the innovative competitiveness.

The figure below reflects the foreign PhD students as a percentage of all PhD students. The proportion of foreign students indicates the mobility of individuals for diffusing knowledge. When the ratio of high-skilled foreign PhD students increases, the attractiveness of the research system is boosted (Global Innovation Index, 2019).

Various countries set certain policies and prepare legal regulations regarding the retention of highly-skilled immigrants or PhD graduates. To keep them within the country and national innovation eco-system, foreign PhD students are provided with a long-term residence permit and are allowed to access to risk capitals and research funds in the host country. It is obvious that they have a positive impact on innovation. The figure below shows foreign PhD students as a percentage of all PhD students in the EU.

Figure 6: Share of Foreign Doctorate Students
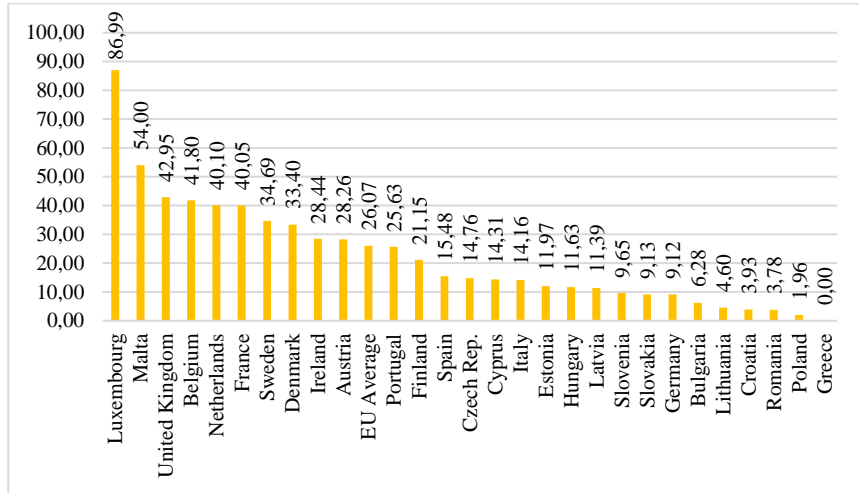
Source: (European Innovation Scoreboard, 2018).

As indicated in the figure, the EU country with the highest percentage of foreign PhD students is Luxembourg, and Malta ranks as the 2nd country. These are countries with the lowest population in the EU. Both countries have more foreign PhD students than national students. The UK, which has a world-renowned international higher education system, is the 3rd country. Belgium and The Netherlands follow the UK. No data is available about Greece, and Poland is at the end of the list.

Interestingly, Germany ranks as the 7th country with the lowest number of foreign PhD students. France, on the other hand, is the 6th country with the highest number of foreign PhD students. France score in this parameter indicates that it has a well-established mechanism for the mobility of researchers.

4.3.2. Scientific Talent

The knowledge created by publicly-funded research spills over the economy and the knowledge is transferred from its source to other stakeholders like private companies. Universities and research centres produce skills and new ideas. Initially, these institutions conduct basic scientific research, create new knowledge and provide scientific capital. Then, dissemination process of the knowledge starts and universities train human capital. It is the academic dimension and process of production of scientific knowledge. In addition to that, certain research results and findings are directly transferred to the private sector or the research is conducted in cooperation with the private sector. It is called as the transfer

of scientific knowledge from academia to the private sector. By some means or other, there is a positive relationship between academic research, productivity and growth. The universities contribute to economic growth through innovations and this contribution may be direct if researchers and scientists produce innovation or indirect if university researchers and scientists cooperate with private businesses. In this context, education plays an important role in terms of increasing innovative capability by producing new ideas (Schneider & Sørensen, 2019).

In this regard, the capability of universities and research centres to produce knowledge is crucial. Similar to the quantity of R&D expenditure or the number of academic researchers, the capability of a country's knowledge production is measured through the number of publishing.

The table below retreated from World Bank (2016) database refers the articles of scientific and technical disciplines such as physics, biology, chemistry, mathematics, clinical medicine, biomedical, engineering, technology and sciences in 2016 per 1000 persons. Articles are counted from the journals covered by the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Also, population data of the countries and the total number of articles are stated in the table.

Table 1: European Countries' Scientific and Technical Publishing Per Thousand Population

	COUNTRY	NUMBER of ARTICLES (2016)	POPULATION (2016)	PUBLISHINGS PER 1000 PERSONS
1.	Denmark	13733	5707251	2,40
2.	Sweden	19937	9851017	2,02
3.	Finland	10545	5487308	1,92
4.	Netherlands	29949	16979120	1,76
5.	Slovenia	3407	2064188	1,65
6.	Czech Republic	15963	10553843	1,51
7.	United Kingdom	97527	65382556	1,49
8.	Belgium	16394	11311117	1,44
9.	Ireland	6834	4726286	1,44
10.	Austria	12366	8700471	1,42
11.	Luxembourg	818	576249	1,41
12.	Portugal	13733	10341330	1,32
13.	Germany	103122	82175684	1,25
14.	The EU Average	613774	510277177	1,20
15.	Cyprus[1]	973	848319	1,14

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[1] Greek Cypriot Administration of Southern Cyprus.

16.	Italy	69125	60665551	1,13
17.	Spain	52821	46440099	1,13
18.	Estonia	1482	1315944	1,12
19.	France	69431	66730453	1,04
20.	Greece	10725	10783748	0,99
21.	Slovakia	5359	5426252	0,98
22.	Croatia	4056	4190669	0,96
23.	Poland	32978	37967209	0,86
24.	Lithuania	2181	2888558	0,75
25.	Malta	320	450415	0,71
26.	Latvia	1257	1968957	0,63
27.	Hungary	6208	9830485	0,63
28.	Romania	10194	19760314	0,51
29.	Bulgaria	2559	7153784	0,35

Source: (World Bank, 2016) (Scientific and Technical Journal Articles), (Eurostat, 2016) (Population), Author (Calculations).

As shown in the figure aforementioned, Denmark, Sweden and Finland are the countries with the highest performances in the EU. The Netherlands and Slovenia follow them in the top five. The UK ranks as 7th and Germany ranks as 13th right above the EU average. France ranks as the 19th with much lower performance than the EU average. While there are 2,4 articles per 1000 persons in Denmark, it is 1,04 in France, which can be explained as 2 times more successful performance. Countries with the lowest performances in the EU are Bulgaria and Romania. 0,35 article is produced per 1000 persons in Bulgaria which is 6,5 times less than Denmark on the top of the list.

In addition to the number of scientific publications produced by countries, the contribution of these publications to science, namely scientific quality, is of great importance. The quality of scientific publications is generally measured by the number of citations. The ability of the countries to make publications among the most-cited publications worldwide reveals the scientific value of these publications.

The European Innovation Scoreboard index calculates the ratio of the total number of scientific publications of the EU member and partner countries in the top 10% of the world's most-cited publications and considers them as an effective parameter in the innovation scoreboard index.

The figure below can be interpreted as the efficiency of the research system since highly-cited publications are considered as higher quality. However, it must be annotated that the UK and Ireland are English-speaking countries, thus their academic and scientific productions are all English, which simplifies citations.

Figure 7: Scientific Publications Among the Top 10% most Cited Publications Worldwide as % of Total Scientific Publications of the Country (2015)
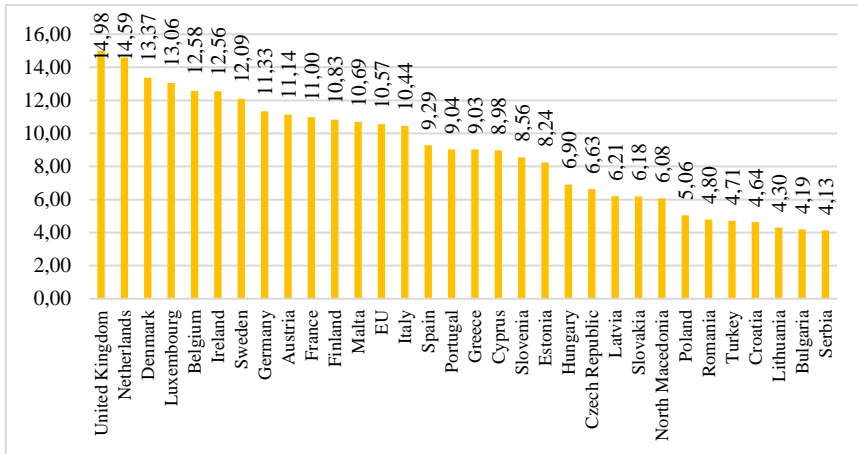
Source: (European Innovation Scoreboard, 2018)**.**

As indicated in the figure, the most successful countries are the UK, the Netherlands, Denmark, Luxembourg and Belgium respectively. Germany ranks as the 8th and France ranks as the 11th in the list. Both countries are above the EU average while the countries like Italy, Spain, Portugal, Greece and Poland fall below the EU average. The countries with the lowest performance in the EU are Bulgaria, Lithuania and Croatia. The UK and the Netherlands are nearly 4 times more successful than Bulgaria and Lithuania. However, this data has a limitation. Most of the academic papers which are cited are English. As the official language of the UK is English, national academic papers are written and published in English as well. In this context, all the papers produced within the UK have an international dimension and high level of possibility to be cited.

4.4. Innovative Collaboration with Industries

The fiery competitive environment has changed the role of the universities and imposed them to expend more energy on innovation today. Universities have started to develop a new partnership with companies, foundations and other research institutions. The main target is not only transferring knowledge from labs to practice but also providing funds for talents and students to conduct their research and exchange ideas outside the academia (World Economic Forum, 2019). When the reports prepared by the European Commission are considered, 70% of the innovative outcomes in the R&D projects funded by the EU are supported by universities. The

cooperation between SMEs and universities is quite satisfactory. The contribution of universities cannot be denied, especially in the process of developing new products. The cooperation of private companies with each other is an important output of the projects and is important in terms of new processes, services and organizational methods. In this context, it can be inferred that universities have an important role in the process of innovation production, but private companies have a more important role in the process of innovation and commercialization. Therefore, it should be stated that universities have a complementary position in the process of innovation and contribute to private companies or SMEs. Universities and private organizations must meet different requirements and fulfil different roles to make the market potential of an innovation a reality. Universities mostly deal with the process of making the needs analysis, reporting, researching and preparing the final requirements. Private companies, however, are busy with the commercialization of the innovation, market creation for the product and spreading in the market. Therefore, it can be said that the innovations that emerged after the EU funded projects are always the product of solidarity. In this solidarity, SMEs, higher education institutions and research institutions and the private sector are stakeholders (Pesole & Nepelski, 2016). GIS assesses the countries university-industry research collaboration capability by certain variables. The table below indicates the list of performance of the EU countries.

Table 2: University-Industry Collaboration

1.	Finland	77.41	**15.**	Estonia	48.16
2.	Netherlands	76.12	**16.**	Czech Republic	47.64
3.	United Kingdom	73.09	**17.**	Italy	46.45
4.	Germany	72.91	**18.**	Slovenia	46.05
5.	Belgium	71.11	**19.**	Spain	41.04
6.	Sweden	70.70	**20.**	Hungary	40.54
7.	Ireland	67.39	**21.**	Cyprus	40.03
8.	Luxembourg	63.57	**22.**	Bulgaria	39.30
9.	Austria	63.54	**23.**	Slovakia	36.68
10.	Denmark	62.50	**24.**	Poland	37.06
11.	France	53.68	**25.**	Romania	35.70
12.	Portugal	53.24	**26.**	Latvia	34.45
13.	Lithuania	50.88	**27.**	Croatia	28.76
14.	Malta	50.00	**28.**	Greece	25.81

Source: (Global Innovation Index, 2019).

Providing students and academics with an environment to share/exchange their ideas and projects inside and outside of their university is a key instrument preparing them for changing world. According to GIS

University/Industry Research Collaboration Index, France is the 11th in the EU and 34th in the world. Finland ranks the 1st, The Netherlands ranks the 2nd and the UK ranks the 3rd in the list. The least successful country in the EU is Greece. Position of France is on the average among the countries.

5. Conclusion

The study aimed to reveal the innovative competitiveness of France's science and research area and analysed various indicators which are directly or indirectly related to research capacity of France and the EU countries. Initially, France allocates 2,2% of its GDP in R&D spending and ranks as the 7th country in the EU while certain EU countries such as Sweden and Austria allocate more than 3% and Germany allocates around 2,9%. Denmark, Finland and Belgium make more investment in R&D than France in terms of % of their GDP. Even though France is one of the largest economies in the EU, its investment in R&D is not parallel to its position in terms of economic size. Additionally, France's R&D investment per inhabitant in HES is 3 times less than Denmark. France ranks as the 10th position in R&D expenditure per inhabitant in HES. It is necessary for France to allocate more money for R&D expenditures as the allocation for R&D is not sufficient. France's human capital in science and research sector is not as comparable as the North European countries such as Denmark, Sweden and Finland. The number of full-time researchers in France is 4307,2 while it is 7514 in Denmark and 7153,4 in Sweden. France ranks as the 11th in the EU. Also considering the new doctorate graduates per thousand population, France performs poorly and hosts even fewer graduates than the EU average. In the measurement of the mobility of researchers, France ranks 6th in the share of foreign doctorate students in the EU. In this context, it is also necessary for France to invest in its human capital, employ more researchers, support PhD graduates' mobility and integrate more PhD graduates into the system.

Innovative competitiveness of a research system is also assessed with its capability to produce knowledge. In scientific and technical publishing per thousand population, France ranks as 19th in the EU and produces 1,04 papers per thousand population- where it is 1,20 in the EU average. Thus, France falls behind the EU average in terms of scientific and technical publishing. Additionally, France's position in the parameter of scientific publications among the top 10% most cited publications worldwide as % of total scientific publications is the 10th among the EU countries, the UK ranks the 1st and Germany ranks the 8th. Lastly, according to university-industry research collaboration measurement of GIS, France ranks 11th in

the EU, falling behind the UK, the Netherlands, Germany, Belgium, Ireland, Austria and Denmark.

In conclusion, France which is a founding member of the EU is the third-largest economy in the Union right now. However, the economic size of the country is not parallel with its development level of science and research area. Especially in the information age which innovative capability of the countries is crucial, France should make more investment in R&D spending, human capital in science and higher education sector and scientific productivity to increase its competitiveness for innovation.

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