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EXPLORING THE DYNAMICS OF INNOVATION: A COMPARATIVE STUDY OF NORDIC AND WESTERN EUROPEAN COUNTRIES

Studie dynamiky inovací: Srovnávací studie severských a západoevropských zemí

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Annotation
The study aims to employ a comparative analysis of various indicators such as R&D expenditure, patent applications, human resources in R&D, and employment in high-tech sectors to identify similarities and differences in innovation performance between the two groups of countries: the Nordic countries (Finland and Sweden) and Western European countries (Netherlands and Belgium). The researchers collected data from Eurostat to conduct the analysis. The methodology used a comparative approach to identify notable trends or differences between the Nordic and Western European regions based on results from innovation indicators. While the researchers were able to present data on human resources in science and technology (HRST) and the percentage of employment in high-tech sectors for NUTS 2 regions, other two indicators gross domestic expenditure on R&D and patent applications are analyzed from country perspective due to the lack of data available for some regions. Nonetheless, using indicators for both country and NUTS 2 provides valuable insights into the innovation performance from both a country and regional perspective. The study finds that Nordic countries generally perform better in terms of innovation indicators in high sectors compared to the other Western European countries.

Keywords
R&D, science and technology, patent, Nordic countries, Western European countries

Anotace
Cílem článku je použít srovnávací analýzu různých ukazatelů, jako jsou výdaje na výzkum a vývoj, patentové přihlášky, lidské zdroje ve výzkumu a vývoji a zaměstnanost v odvětvích špičkových technologií ke zjištění podobností a rozdílů v inovační výkonnosti mezi dvěma skupinami zemí: severskými zeměmi (Finsko a Švédsko) a zeměmi západní Evropy (Nizozemí a Belgie). Pro analýzu byla využita data z Eurostatu. Dále byl využit komparativní přístup k identifikaci významných trendů nebo rozdílů mezi severskými a západoevropskými regiony na základě výsledků inovačních indikátorů. Zatímco údaje o lidských zdrojích ve vědě a technice (HRST) a procentu zaměstnanosti v high-tech sektorech byly dostupné pro regiony NUTS 2, další dva ukazatele jsou analyzovány z pohledu jednotlivých zemí z důvodu nedostatku dostupných údajů pro některé regiony. Jedná se o ukazatele hrubých domácí výdajů na VaV a patentové přihlášky. Použití indikátorů celostátní úrovně i úrovně NUTS 2 poskytuje cenné poznatky o inovační výkonnosti z pohledu států i regionů. Výsledky ukázaly, že severské země si ve srovnání s ostatními západoevropskými zeměmi vedou lépe v oblasti inovačních ukazatelů u high-tech sektorů.

Klíčová slova
výzkum a vývoj, věda a technologie, patent, severské země, země západní Evropy

JEL Classification: *O39*

1 Introduction

Innovation is a driving force behind economic growth and social progress, making it an essential factor in a country's development. Innovation indicators such as research and development (R&D) expenditure, patent applications, human resources in R&D, and employment in high-tech sectors provide valuable insights into a country's innovation performance. R&D expenditure measures the amount of resources a country dedicates to research and development, while patent applications reflect the innovative output of a country's research efforts. Human resources in R&D represent the capacity of a country to undertake R&D activities, and employment in high-tech sectors indicates the degree to which a country's economy is oriented towards technology-intensive industries. The occurrence of innovation ensures that the resources of the country and society are transformed into products and services, and it is possible to create economic and social value from these products and services. With innovation, society gains more efficiency from existing resources. Therefore, it can be said that innovation is not only an economic but also a social system (Elçi, 2006).

Nordic and Western European countries have distinct historical, cultural, and institutional contexts that can shape their approaches to innovation. Innovation indicators are essential in tracking a country's progress towards economic development and competitiveness. They provide policymakers, researchers, and businesses with valuable insights into the strengths and weaknesses of an innovation ecosystem, enabling them to identify areas for improvement and promote innovation-driven growth.

2 Literature review

According to Moutinho et al. (2015), industrial sectors that have a high proportion of R&D employment often have numerous new and rapidly growing companies. Additionally, companies with strong capabilities to enhance technological competence can achieve sustained growth by utilizing their accumulated knowledge to develop their technological endowments. Dziallas and Blind (2019) used in their study a wide range of innovation indicators used throughout the innovation process, including inputs such as research and development expenditures, human resources, and intellectual property, as well as outputs such as new products, patents, and revenues. The authors also discussed the use of composite indicators, which combine multiple measures of innovation into a single score. The article highlights the importance of selecting appropriate innovation indicators based on the stage of the innovation process and the specific context of the innovation. In the study by Onea (2020), comprehensive review of the literature on innovation indicators, focusing on their use in measuring different aspects of the innovation process, including inputs, outputs, and outcomes. The author discusses the strengths and weaknesses of various innovation indicators and the challenges of measuring innovation in different contexts was provided. The study showed the findings of an analysis of the EIS data, which provided evidence of the relationship between innovation indicators and the innovation process in the EU. The analysis showed that inputs such as R&D expenditures, human resources, and intellectual property are positively associated with innovation outputs such as patents, new products, and exports.

Barbero et al. (2021) argued that innovation may not always increase linearly with investment and output, and that there may be a point where further investment in innovation leads to diminishing returns. The authors also proposed a conceptual framework for understanding the relationship between decreasing returns to scale and innovation. Oort (2017) highlighted the importance of spatially bounded externalities in shaping urban growth and innovation. These externalities refer to the ways in which firms, individuals, and institutions benefit from being in close proximity to each other, and include knowledge spillovers, labor market pooling, and technology diffusion. While Hall and Mairesse (1995) took R&D as the main innovation indicator in their study, in the following years, Archibugi and Coco, A. (2004) added patent and research publication to this list in their research. Shi, and Yang (2022) additionally used innovation surveys as indicators in their research.

3 Objectives and Methodology

The overarching objective of this research paper is to compare the innovation performance of two groups of countries - the Nordic countries (Finland and Sweden) and Western European countries (Netherlands and Belgium). This objective will be achieved by using various indicators such as R&D expenditure as a percentage of GDP, patent applications, human resources in R&D, and employment in high-tech sectors to compare the innovation performance of these countries. By conducting a comparative analysis of these indicators, the aim is to

identify similarities and differences in innovation performance between the two groups of countries, and provide recommendations for policy-makers and stakeholders in these countries to enhance their innovation performance.

Nordic countries (Sweden and Finland) and Western European countries (Netherlands and Belgium) were selected for comparison based on their geographical proximity and similarities in their economic and social systems. We then compared the regions based on several indicators related to R&D expenditure, patent applications, human resources in R&D, employment in high-tech sectors. For the country comparison, data was collected for R&D expenditure and patent applications to the EPO by country of applicants and inventors. For the NUTS 2 regions comparison, data was collected on human resources in science and technology (HRST) by NUTS 2 regions and employment in high-tech sectors and both data were collected from Eurostat. Researchers used a comparative approach to identify similarities and differences between the Nordic countries and Western European countries based on results from innovation indicators. To compare R&D expenditure as a percentage of GDP between 2016 and 2020, researchers calculated the average and median values for Nordic and Western European regions to compare their innovation performance. To analyze human resources in science and technology (HRST) and employment in high-tech sectors in NUTS 2 regions ranked method is used based on these indicators and presented the results in tables to identify similarities and differences between the Nordic and Western European regions.

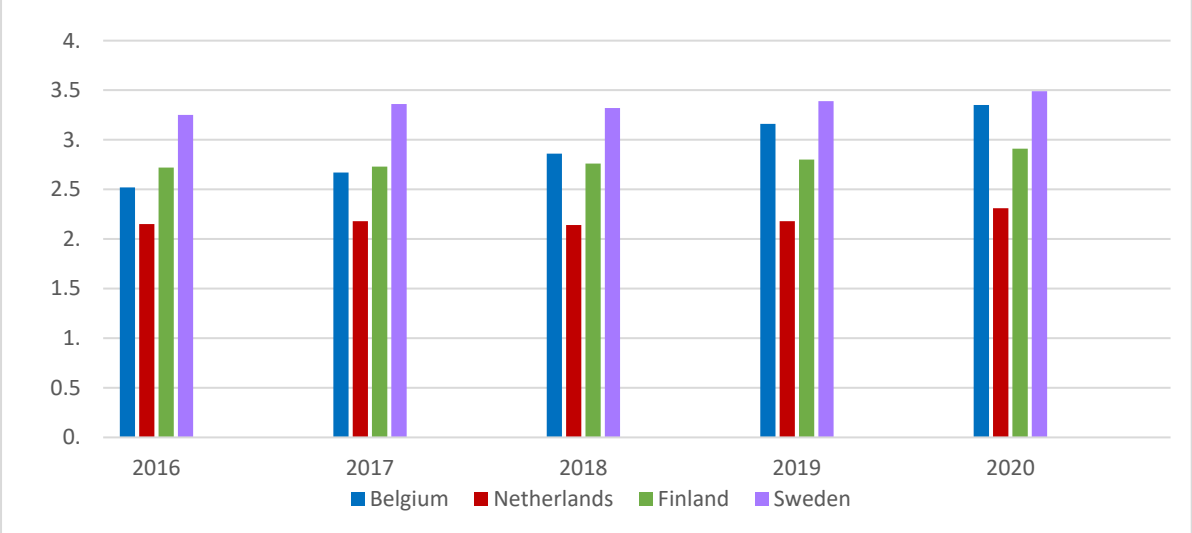
It is important to note that due to the lack of data available for some NUTS 2 regions, only two indicators - human resources in science and technology (HRST) and the percentage of employment in high-tech sectors - were able to be presented for these regions. However, using indicators for both country and NUTS 2 regions provide valuable insights into the innovation performance from both a country and regional perspective.

4 Results

4.1 Gross domestic expenditure on R&D (GERD)

From the dataset provided in Figure 1, it is possible to see that the four countries - Belgium, Netherlands, Finland, and Sweden, have all increased their expenditure on Research and Development (R&D) as a percentage of gross domestic product (GDP) between 2016 and 2020. In 2020, Sweden had the highest expenditure on R&D as a percentage of GDP at 3.49%, followed by Belgium at 3.35%, Finland at 2.91%, and the Netherlands at 2.31%.

Fig. 1: GERD by sector of performance and fields of R&D Source (as a percentage of gross domestic product (GDP))



Source: Eurostat (2023)

Based on calculation of the average and median expenditure on R&D as a percentage of GDP for both groups of countries over the period 2016-2020:
Nordic countries (Finland and Sweden)

- Average: 3.14%
- Median: 3.32%

Western European countries (Belgium and the Netherlands)

- Average: 2.47%

- Median: 2.31%

On average, the Nordic countries have a higher expenditure on R&D as a percentage of GDP compared to the Western European countries. This is also reflected in the median values, where the median for the Nordic countries is higher than the median for the Western European countries.

One possible explanation for the higher R&D expenditure in the Nordic countries is their strong tradition of innovation and technological advancement. Nordic countries have a long history of investing in education and research, which has resulted in a highly educated workforce and a culture that values innovation. The Nordic countries have also implemented policies to encourage R&D investment, such as tax incentives and funding programs for research institutions and private companies. This may have contributed to the higher R&D expenditure as a percentage of GDP in these countries. On the other hand, the Western European countries may have different priorities for their economic policies. For example, Belgium and the Netherlands may be more focused on maintaining their status as trading hubs and investing in infrastructure and logistics. While R&D is important for innovation and economic growth, it may not be a priority in these countries' economic strategies.

4.2 Human resources in science and technology (HRST)

The Table 2 shows the ranking of different regions based on their NUTS 2 score for the years 2016 to 2020. The higher the NUTS 2 score, the more developed and prosperous a region is considered.

Tab. 2: Human resources in science and technology (HRST) by NUTS 2 regions (% of population in the labour force)

NUTS 2	2016	2017	2018	2019	2020
Stockholm	64.2	64.9	65.8	66.7	67.7
Helsinki-Uusimaa	62.1	61.8	63.1	64.3	65.9
Prov. Brabant wallon	61.8	66.2	66.6	66.4	70.5
Prov. Vlaams-Brabant	58.3	61.9	59.1	60.6	63.1
Utrecht	58.1	60.1	61.8	63.3	64.5
Noord-Holland	56.0	56.6	57.2	59.2	60.3
Sydsverige	54.9	56.0	57.7	58.1	57.1
Västsverige	51.8	52.4	53.5	53.9	55.7
Prov. Oost-Vlaanderen	51.2	54.9	54.2	52.0	55.9
Östra Mellansverige	51.1	51.5	52.0	53.4	54.3
Zuid-Holland	50.6	51.6	52.9	54.0	57.3
Groningen	49.9	49.7	50.3	50.8	53.2
Övre Norrland	48.9	49.1	51.7	51.0	50.6
Åland	48.6	48.2	45.4	45.8	51.3
Länsi-Suomi	48.1	48.8	50.2	51.2	52.9
Prov. Antwerpen	47.9	51.5	52.1	52.0	54.1
Prov. Namur	47.9	53.8	52.5	51.4	53.8
Etelä-Suomi	47.4	48.6	48.9	50.5	53.1
Gelderland	46.6	46.9	48.9	50.9	51.9
Noord-Brabant	46.4	46.6	48.4	50.0	52.1
Prov. Limburg (BE)	46.3	47.8	47.3	49.2	51.6
Prov. Liège	46.3	48.2	49.3	51.9	53.1
Prov. Luxembourg (BE)	46.1	46.5	49.5	50.8	52.9
Prov. West- Vlaanderen	45.8	48.5	47.9	47.3	48.8
Norra Mellansverige	45.7	45.9	46.9	45.5	47.6
Overijssel	45.0	45.6	46.7	48.0	50.0
Flevoland	44.9	47.2	44.9	48.7	51.5
Mellersta Norrland	44.9	47.5	49.8	51.2	52.2
Småland med öarna	44.7	45.1	47.0	47.8	49.1
Pohjois- ja Itä-Suomi	44.5	46.2	47.0	48.1	49.2
Limburg (NL)	43.3	44.2	44.8	46.3	48.1
Prov. Hainaut	42.7	45.3	45.9	46.8	47.6
Drenthe	42.3	42.2	44.5	46.4	48.1
Zeeland	40.0	42.2	42.3	42.2	45.1
Friesland (NL)	39.8	41.2	43.9	45.8	46.6

Source: Authors' calculation with data from Eurostat (2023)

NUTS 2 regions in Nordic countries - The highest HRST values are seen in Stockholm. The Helsinki-Uusimaa andLänsi-Suomi regions of Finland have consistently high HRST, with Helsinki-Uusimaa coming in second after Stockholm in most years.
NUTS 2 regions in Western Europe countries - Regions with high HRST values include Prov. Vlaams-Brabant, Utrecht, and Noord-Holland and regions with lower HRST values include Friesland (NL), Zeeland, Prov. Hainaut, Limburg (NL), Pohjois- ja Itä-Suomi, and Småland med öarna. These regions have HRST values consistently below 50.
The ranking suggests that the Nordic countries are leading in terms of human resources in science and technology, with several regions consistently ranking high in the HRST score. On the other hand, some Western European countries have regions that are lagging behind in terms of human resources in science and technology, indicating that there may be a need for policies that promote education and training in these fields in these regions.

4.3 The percentage of employment in high-tech sectors

The Table 3 shows the percentage of employment in high-tech sectors for various NUTS 2 regions in Europe for the years 2016-2020.The regions with the highest employment in high-tech sectors are Helsinki-Uusimaa, Stockholm, and Prov. Brabant wallon, with percentages ranging from 8.8% to 10.4%. There is a wide variation in the percentageof employment in high-tech sectors among the different regions, with some regions having less than 2% and others having more than 10%. Some regions with weaker high-tech employment include Friesland (NL), Zeeland, and NorraMellansverige, all of which had employment percentages below 3% in 2020.

Tab. 3: The percentage of employment in high-tech sectors (percentage of total employment)

NUTS 2 regions	2016	2017	2018	2019	2020
Helsinki-Uusimaa	9.5	9.4	9.6	9.7	10.2
Stockholm	7.9	8.4	9.3	9.7	10.4
Prov. Brabant wallon	7.2	6.7	7.8	8.6	8.8
Prov. Vlaams-Brabant	6.5	7.0	6.5	6.5	6.9
Région de Bruxelles-Capitale	5.8	6.1	7.4	6.6	6.6
Utrecht	5.5	5.2	5.7	6.0	6.5
Prov. Antwerpen	5.0	5.5	5.8	6.4	5.7
Noord-Holland	4.9	4.8	4.8	5.3	5.5
Sydsverige	4.9	5.2	4.8	4.6	5.1
Prov. Namur	4.8	5.5	5.9	5.9	5.4
Zuid-Holland	4.4	4.2	4.1	4.1	4.6
Östra Mellansverige	4.3	4.2	4.4	4.9	4.9
Flevoland	4.1	4.1	3.7	4.7	4.8
Noord-Brabant	4.1	3.8	3.6	3.8	4.1
Västsverige	4.1	4.4	4.4	4.3	4.7
Prov. Oost-Vlaanderen	4.0	4.6	4.4	5.0	5.1
Groningen	4.0	3.8	4.1	4.0	4.3
Länsi-Suomi	3.9	4.0	3.8	4.3	4.5
Pohjois- ja Itä-Suomi	3.7	3.9	4.1	4.2	5.1
Etelä-Suomi	3.5	3.4	3.7	4.1	5.1
Prov. Hainaut	3.4	3.2	4.3	4.1	3.8
Gelderland	3.4	3.3	3.7	4.2	4.0
Overijssel	3.1	3.0	3.3	3.3	3.5
Övre Norrland	3.1	2.6	2.9	2.8	3.6
Norra Mellansverige	2.9	2.8	2.5	2.1	1.9
Mellersta Norrland	2.9	3.9	3.8	3.7	4.4
Prov. Limburg (BE)	2.8	3.0	2.5	3.5	4.7
Drenthe	2.8	2.5	2.0	2.2	2.8
Prov. West-Vlaanderen	2.7	2.8	2.6	2.8	2.6
Prov. Liège	2.6	2.4	3.5	3.7	3.9
Limburg (NL)	2.5	2.4	2.6	2.8	2.6
Prov. Luxembourg (BE)	2.3	3.5	2.9	2.7	3.0
Zeeland	2.0	1.8	1.8	2.0	1.4
Småland med öarna	2.0	2.0	2.0	2.5	2.5
Friesland (NL)	1.8	1.5	1.7	1.8	1.8
Åland	:	:	:	:	:

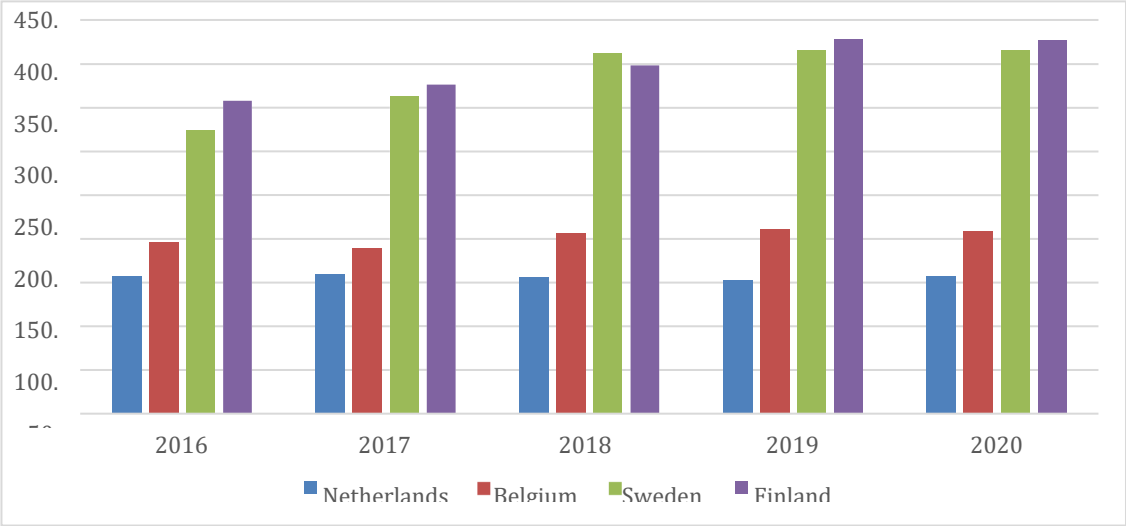
Source: Authors' calculation with data from Eurostat (2023)

Several factors could explain the differences between regions. Firstly, it is essential to note that high-tech sectors require a highly skilled workforce, which is not easily available in every region. Regions with well-established universities and educational institutions offering STEM (Science, Technology, Engineering, and Mathematics) courses can provide a steady supply of skilled labor to the high-tech sectors. Additionally, regions with a higher concentration of high-tech firms and research centers create a cluster effect that attracts and retains highly skilled workers.

4.4 Patent applications to the EPO by country of applicants and inventors

Looking at the data in Figure 2, it appears that Sweden and Finland have consistently high numbers of patent applications to the European Patent Office (EPO) by both applicants and inventors. Both countries have seen steady growth in their patentapplications over the years. On the other hand, the Netherlands has seen a slight decrease in patent applications in recent years, but the numbers have remained relatively stable overall. Belgium, on the other hand, has had a more volatile pattern of patent applications, with highs and lows over the years. The Nordic countries (Sweden and Finland) in the given data have higher patent application numbers compared to the Netherlands and Belgium. In 2020, Finlandhad the highest number of patent applications at 427.10, followed by Sweden at 414.99. The Netherlands had 157.08,and Belgium had 208.52.

Fig. 2: Patent applications to the EPO by country of applicants and inventors (per million inhabitants)



Source: Eurostat (2023)

The more developed NUTS 2 regions in Finland is Uusimaa, while in Sweden, is more developed. In the Netherlands, the more developed region is Zuid-Holland, while in Belgium, Flemish Brabant (Vlaams Brabant) and Antwerp are more developed. Overall, these regions have a higher concentration of innovative companies, research institutions, and highly skilled professionals, which has led to a greater number of patent applications. Patents are an important measure of innovation, as they represent the legal protection of an invention, and their high numbers suggest a more innovative and economically successful region. These regions have also likely benefited from supportive government policies and investment in research and development.

The results show that the Nordic countries (Sweden and Finland) generally outperform the Western European countries (Netherlands and Belgium) in terms of innovation indicators. Sweden and Finland have higher R&D expenditure as a percentage of GDP than the Netherlands and Belgium, and they also have a higher number of patent applications per capita. Additionally, the Nordic countries have a higher share of employment in high-tech sectors than the Western European countries. The share of GERD as a percentage of GDP is also higher in the Nordic countries. In terms of human resources in R&D, the Nordic countries have a higher number of researchers per capita than the Western European countries. However, when comparing the NUTS 2 regions within the countries, the Western European regions outperform the Nordic regions in terms of human resources in science and technology.

Conclusion

The analysis of the data shows that the Nordic countries generally perform better than the Western European countries in terms of innovation indicators. This suggests that the Nordic countries are investing more in research

and development, which is contributing to their strong innovation performance. One possible explanation for the superior innovation performance of the Nordic countries is their strong institutional support for innovation. The Nordic countries have a long history of supporting innovation through public-private partnerships, research funding, and a supportive business environment. Additionally, these countries have a strong tradition of collaboration between academia and industry, which has facilitated the transfer of knowledge and technology from research to commercial applications. The Western European countries, on the other hand, have a more diverse economic structure with a larger service sector, which may explain their lower levels of R&D expenditure and employment in high-tech sectors. Additionally, these countries may have a more complex institutional landscape, which can create challenges for collaboration and innovation. Despite these differences, both the Nordic and Western European countries have demonstrated the importance of investing in R&D, human resources in R&D, and patent applications for driving innovation. These indicators can serve as useful tools for policymakers and researchers to evaluate a country's innovation performance and identify areas for improvement.

In conclusion, this research paper has compared the innovation performance of Nordic and Western European countries using several indicators related to R&D expenditure, patent applications, human resources in R&D, and employment in high-tech sectors. The analysis has shown that the Nordic countries generally perform better. however, both groups of countries have demonstrated the importance of investing in R&D, human resources in R&D, and patent applications for driving innovation. This research has important implications for policymakers and researchers interested in promoting innovation-driven growth. The indicators used in this study can serve as useful tools for evaluating a country's innovation performance and identifying areas for improvement. By investing in R&D, human resources in R&D, and patent applications, countries can create an innovative ecosystem that supports economic growth and social progress.

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