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Exploring the dynamics of innovation:

a comparative study of Nordic and western European countries

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Research Topic (Abstract)

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.

Objectives and Keyword

Objectives:

- Research and development expenditures
- R&D personnel
- Patents
- Human resources in science and technology

Keywords:

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

Literature review

Moutinho et al. (2015) - industrial sectors that have a high proportion of R&D employment often have numerous new and rapidly growing companies.

Dziallas and Blind (2019) highlighted the importance of selecting appropriate innovation indicators based on the stage of the innovation process and the specific context of the innovation

Onea (2020) 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.

Literature review

Barbero et al. (2021) 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.

Hall and Mairesse (1995) took R&D as the main innovation indicator in their study. **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.

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Literature review

- **Klofsten et al. (2015),** highlighted some regions in Nordic countries are more successful than others in fostering innovation and entrepreneurship, which can lead to uneven development.
- As noted by **Berglund and Johansson (2007),** while the Nordic countries are known for their high levels of gender equality and social inclusion, there is still work to be done to ensure that underrepresented groups have access to resources and support for innovation. Addressing these diversity and inclusion challenges will require efforts to promote greater representation of underrepresented groups in innovation ecosystems and to remove barriers to their participation
- According to a study by **Hedner et al. (2010)** Nordic incubators often prioritize companies that have a positive social or environmental impact, and many offers specialized support for green or social ventures.

Objectives and aim

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 is 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 policymakers and stakeholders in these countries to enhance their innovation performance.

Methodology

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.

Methodology

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.

Results
Gross domestic expenditure on R&D (GERD)

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%.

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%

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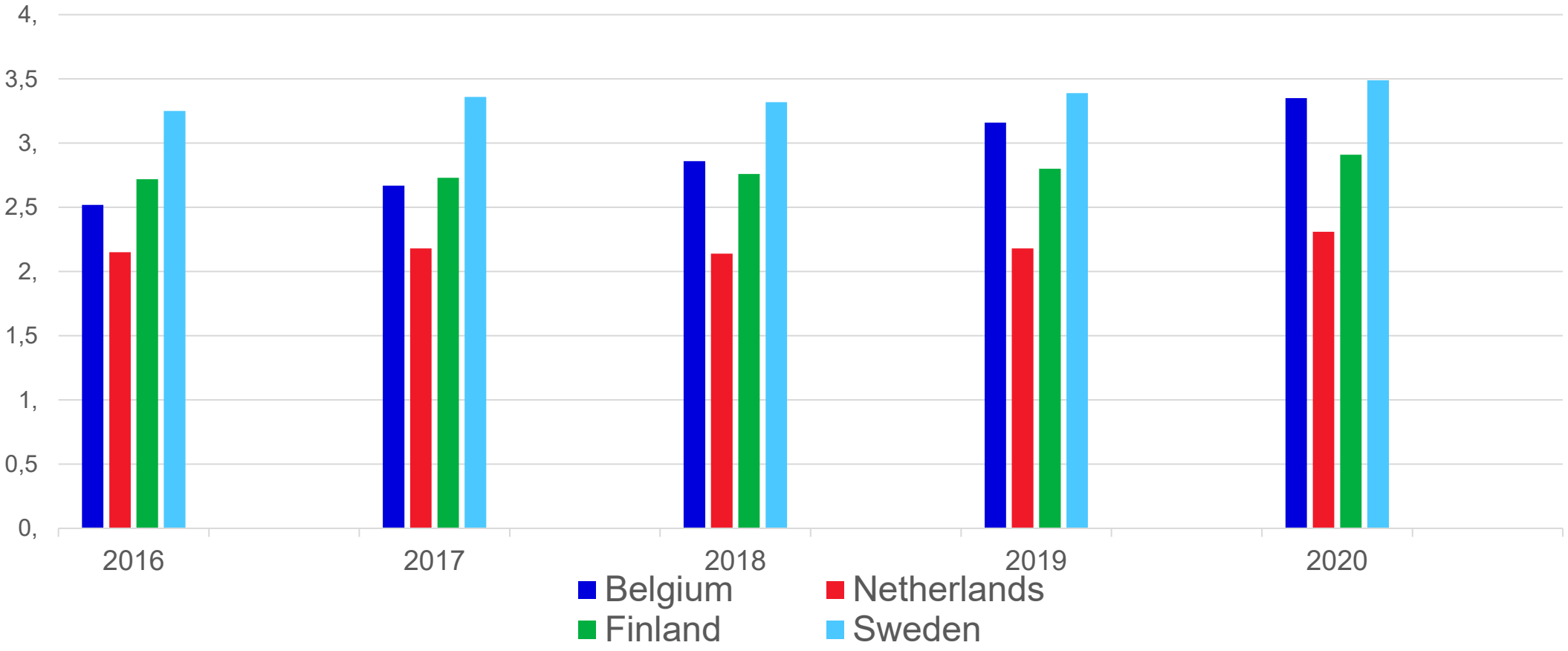
Figure 1. GERD by sector of performance and fields of R&D Source (as a percentage of gross domestic product (GDP))



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Human resources in science and technology (HRST)

NUTS 2 regions in Nordic countries - The highest HRST values are seen in Stockholm. The Helsinki-Uusimaa and Länsi-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.

Table 1. Human resources in science and technology (HRST) by NUTS 2 regions (Percentage 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)

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The percentage of employment in high-tech sectors

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 percentage of 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 Norra Mellansverige, all of which had employment percentages below 3% in 2020.

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.

Table 2. 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/Brussels Hoofdstedelijk Gewest	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)

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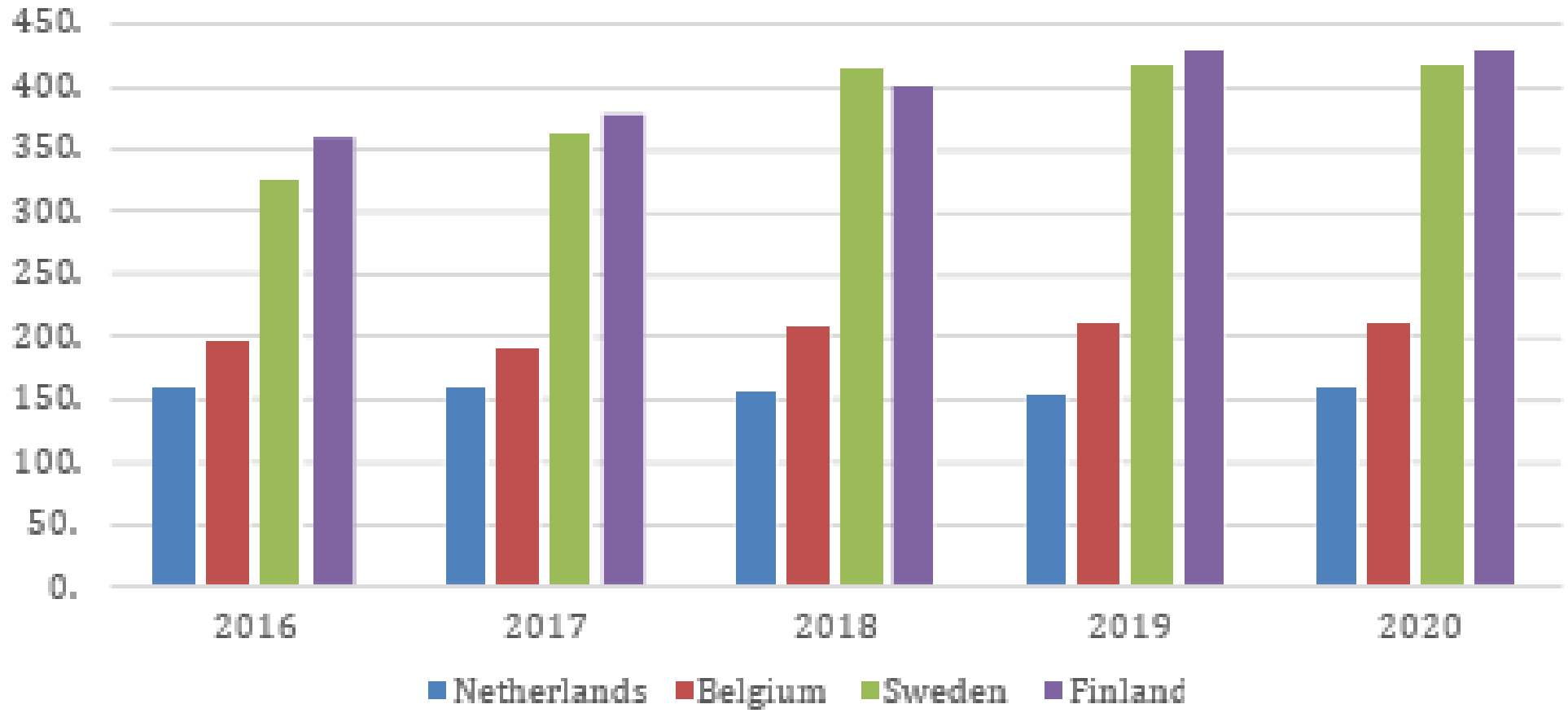
Patent applications to the EPO by country of applicants and inventors

Both countries have seen steady growth in their patent applications 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, Finland had 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.

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.

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



Source: Eurostat (2023)

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Result discussion

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.

Conclusion

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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