Comparing R&D Patterns in Nordic Countries*

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Abstract

In this paper, I analyze the evolution of R&D patterns in three Nordic countries, Denmark, Norway and Sweden. I document substantial differences in industry specialization and also in terms of the respective role of the intensive and extensive margins. I also observe an increased specialization in the different countries, Norway becoming more focused in high tech service industries, while Denmark is increasingly investing in high tech manufacturing like pharmaceuticals and machinery.

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1 Introduction

Despite the widespread recognition that investment in research and development (R&D) is a massive contributor to economic growth, we observe wide dispersion in the intensity through which advanced countries invest in knowledge.[1] At the country level, R&D intensity is measured as the share of total R&D expenses in the country divided by the country GDP. However, this important macroeconomic figure to which policy makers refer to is the aggregation of the individual decisions of thousands of firms in the economy. An increase in R&D intensity can be driven by more firms investing in R&D (the extensive margin) or by firms already involved in R&D increasing their investment relative to the value added they generate (the intensive margin).

Differences are also driven by the comparative advantage and specialization patterns that firms in various countries have created over the years. Some sectors like pharmaceuticals or industrial machinery are more R&D intensive than others. Much of it builds on initial conditions, as these patterns have sometimes taken decades to be built but can also be undone relatively quickly as a consequence of global competition and/or poor strategic decisions.

Consider the case of NOKIA, a pioneer in the age of mobile phones. While being an established global leader until 2010, it failed to adopt the smartphone touchscreen technology, and was quickly taken over by Apple, Samsung and Chinese followers. After gradually losing market share, it eventually sold its mobile phone division to Microsoft and refocused its activities to network equipment, software and services industry.[2] Due to the large global scale of Nokia relative to the Finnish economy, such a dramatic reconversion led to dramatic consequences at the macroeconomic level. The R&D intensity in Finland fell from 3.7% to 2.7% from 2010 to 2016.

In this paper, I use confidential survey data from three Scandinavian countries (Denmark, Norway and Sweden) to analyze the dynamic evolution of firms' R&D decisions over more than three decades. I focus on three basic descriptive facts: 1) how many firms are undertaking R&D investment in each country and what is the average weighted investment? (i.e. looking at the extensive and intensive margin of R&D); 2) in which sectors are firms predominately undertaking R&D in each country in the last year observed in each country? (i.e. looking at the comparative advantage and specialization patterns at snapshot); 3) how have relative sectoral R&D shares evolved over the last decade? (i.e.

[1] See section 2 for a detailed account of these differences.

[2] See e.g. NYT, "Microsoft to Buy Nokia Units and Acquire Executive", Sept. 3, 2013 and The Economist, "Planning the next bounceback", Nov 23rd 2013. Note that Nokia has always been transforming itself through the ages, from selling toilet paper and rubber boots before entering the mobile phone era. A similar picture can be drawn from Samsung, ... or Toyota

looking at the dynamics of comparative and specialization patterns). By examining these three dimensions, we can get a better understanding at how R&D decisions have evolved dynamically and have affected how specialized Scandinavian countries have established themselves over time.

The rest of the paper is divided in four parts. Section 2 discusses the macroeconomic facts about how Scandinavian countries differ in their aggregate R&D intensity. Section 3 discusses the micro data sources and provides basic stylized facts about difference between countries at the micro level. Section 4 looks at sector-specific dynamics over the last decade. Section 5 concludes.

2 Macroeconomic picture

While investment in R&D has been considered as a key determinant for long run growth by economists, European policy makers clearly introduced it as a major component of a renewed policy, the so called Lisbon Agenda in early 2000. The established aim was to make the European Union (EU) the most competitive economy in the world and achieving full employment by 2010. With an average of 2% of GDP in 2003, R&D intensity was lagging behind in Europe compared to the United States (2.8%) and the rest of the OECD (3.1%). The European Council set as an aim to raise these expenditures to 3% of GDP by 2010. The mid-term review held in 2005, for which a report was prepared under the guidance of Wim Kok, former Prime Minister of the Netherlands, showed that these objectives were far from being achieved.

After the financial crisis hit the global economy, the Commission and European leaders launched a renewed agenda labeled "Europe 2020 - The EU strategy for smart, sustainable and inclusive growth". One of the stated objectives was to promote the development of smart growth through knowledge, education and innovation investment. Among the integrated guidelines were two specific targets related to R&D: "optimising support for research, development and innovation, strengthening the knowledge triangle and unleashing the potential of the digital economy" and "developing a skilled workforce responding to labour market needs, promoting job quality and lifelong learning". It was also decided to evaluate the impact of the new measures in a consistent way.

Figure 1 shows the current situation in terms of R&D intensity in the EU. As can be seen, the average is now around 2.3%, far from the 3% initially targeted. It also shows substantial dispersion between EU members, as Belgium and Sweden are leading the charts with a ratio of 3.5%, while some of the new member states like Romania or Malta are still below the 1% threshold.

Figure 1: R&D intensity in EU countries, 2020
(Source: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20211129-2)

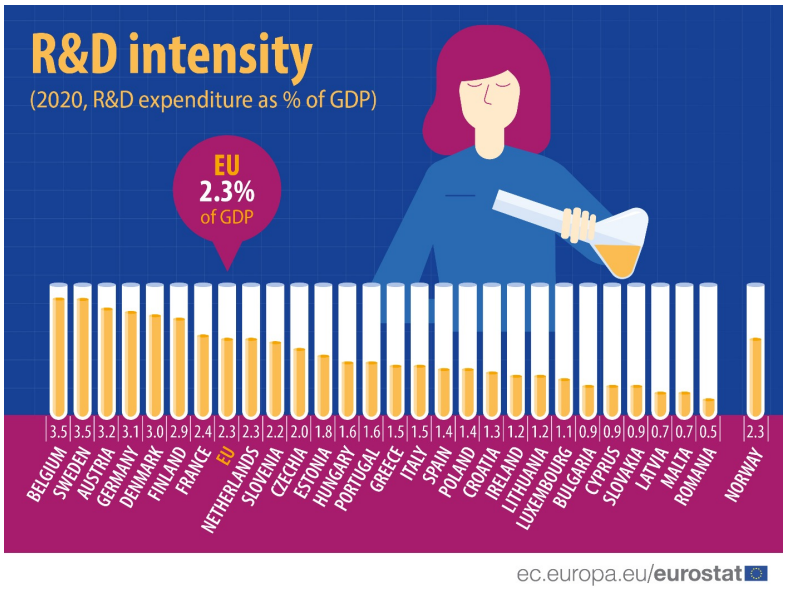


Figure 2: Evolution of R&D intensity in selected EU countries, 2010-2020 (Source: https://ec.europa.eu/eurostat/web/science-technology-innovation/visualisations)

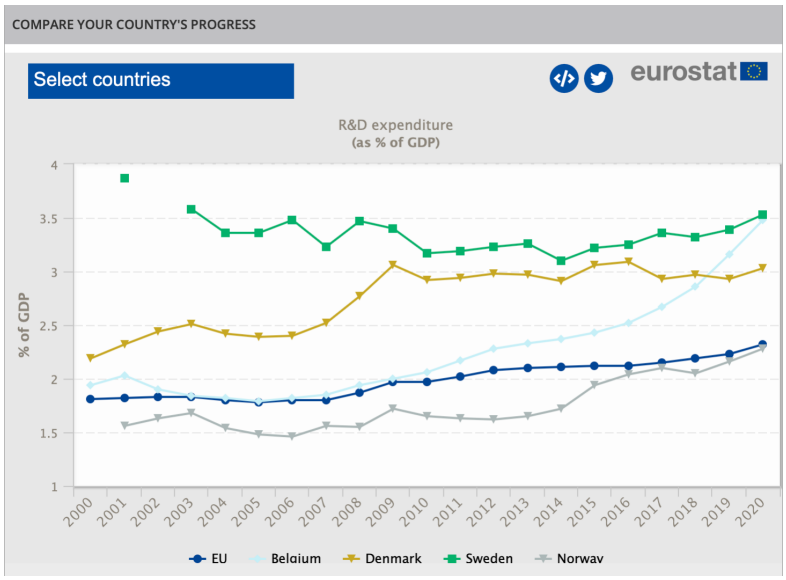


Figure 2 shows the dynamic evolution of the intensity indicator. We can observe an increasing trend for the EU average since 2007, even though at a relatively slow pace. Looking separately at the three Scandinavian countries, we observe that they have followed three distinct trajectories. Sweden has been at the very top around 4% of GDP at the beginning of the years 2000, then suffered from a relative decline until 2014 at around 3.2%, and has since been on the rise again. In the case of Denmark, the ratio jumped spectacularly from 2.5% to 3% between 2006 and 2009, and then remained pretty constant around this level. Finally, looking at Norway, the ratio remained relatively low around 1.6% until 2013, before quickly converging towards the EU average at 2.3% in 2020.

One of the questions I want to investigate in this paper is what is driving this dynamics at the macro level, looking at industry and firm-level dimensions.

3 Data and stylized facts

For several decades, Eurostat in partnership with national statistical institutes has been running the Community Innovation Survey (CIS) asking relatively large companies in industries more likely to be involved in innovation about the nature of their innovation activities. National statistical institutes would typically send the questionnaire including the questions agreed at the European level but could complement them with additional questions, depending on the policy agenda in the country involved. One of the key questions that have been asked consistently over time though is how much firms invest in R&D and how many R&D personnel they employ.

Tables 1 to 3 show the number of firms surveyed and involved in R&D in all three countries, as well as the average amount of R&D spending in nominal domestic currency. We can clearly observe that the number of firms investing in R&D increased much more in Norway than in the other countries, suggesting a substantial role for the extensive margin. On the other hand, the average amount of R&D increased much more in Denmark, stressing the .

Tables 4 to 6 show the most R&D intensive industries in the respective countries in 2017. We can immediately notice important differences in sectorial specialization. R&D appears to be more focused in services than in manufacturing in Norway.

In the next section, I investigate how these specialization patterns evolvd over time in each respective country.

Table 1: Summary statistics on R&D survey, Norway

Year	Number of firms surveyed	Number of firms with positive spending on R&D	Share of surveyed firms investing in R&D	Average spending (in mln NOK)
1997	4,171	863	20.69%	9.07
1998	4,171	863	20.69%	9.07
1999	3,892	806	20.71%	10.75
2000				
2001	3,895	1,079	27.70%	9.73
2002	2,446	852	34.83%	11.97
2003	4,434	1,392	31.39%	8.41
2004	4,655	1,489	31.99%	7.66
2005	4,602	1,296	28.16%	9.34
2006	6,443	1,482	23.00%	9.45
2007	4,685	1,255	26.79%	12.35
2008	6,029	1,516	25.15%	11.28
2009	4,734	1,295	27.36%	12.97
2010	6,595	1,503	22.79%	11.84
2011	4,915	1,305	26.55%	14.48
2012	6,271	1,618	25.80%	12.61
2013	4,709	1,422	30.20%	14.98
2014	4,793	1,507	31.44%	15.26
2015	5,504	1,913	34.76%	13.59
2016	4,891	1,889	38.62%	14.51
2017	5,977	2,288	38.28%	13.24

Table 2: Summary statistics on R&D survey, Denmark

Year	Number of firms surveyed	Number of firms with positive spending on R&D	Share of surveyed firms investing in R&D	Average spending (in mln DKK)
1997	4,077	1,012	24.82%	12.61
1998	4,424	1,017	22.99%	12.73
1999	4,168	1,034	24.81%	13.40
2000				
2001	3,536	566	16.01%	21.89
2002	3,736	697	18.66%	21.91
2003	3,637	723	19.88%	26.24
2004	3,490	618	17.71%	29.90
2005	3,464	692	19.98%	29.79
2006	3,908	599	15.33%	35.66
2007	4,534	841	18.55%	29.13
2008	4,438	1,485	33.46%	19.77
2009	4,545	1,064	23.41%	30.49
2010	4,322	1,027	23.76%	30.44
2011	4,424	983	22.22%	31.85
2012	4,698	1,081	23.01%	31.20
2013	4,787	985	20.58%	33.55
2014	4,901	1,006	20.53%	33.34
2015	5,044	1,044	20.70%	34.56
2016	4,522	1,092	24.15%	35.51
2017	3,321	1,008	30.35%	36.69

Table 3: Share of R&D spending by 2-digit industry (2017), top 25 industries, Norway

Rank	NACE Rev 2	Description	Share R&D spending
1	62	Computer programming, consultancy and related activities	17.13%
2	71	Architectural and engineering services; technical testing and analysis	9.33%
3	58	Publishing activities	8.57%
4	26	Manufacture of computer, electronic and optical products	6.28%
5	28	Manufacture of machinery and equipment n.e.c.	4.36%
6	6	Quarrying of energy producing materials	4.26%
7	25	Fabricated metal products (except machinery and equipment)	4.06%
8	72	Scientific R&D	3.69%
9	20	Chemicals	3.61%
10	61	Telecommunications	3.57%
11	3	Fishing and aquaculture	3.54%
12	10	Food	3.47%
13	64	Financial services	2.95%
14	46	Wholesale	2.18%
15	30	Other transport equipment	1.93%
16	65	Insurance and pension funds	1.84%
17	24	Basic metals	1.63%
18	9	Printing and reproduction of recorded media	1.51%
19	21	Pharmaceuticals	1.37%
20	70	Activities of head offices; management consultancy activities	1.32%
21	27	Manufacture of electrical equipment	1.29%
22	33	Repair and installation of machinery and equipment	1.25%
23	74	Other professional, scientific and technical activities	1.12%
24	63	Information service activities	1.00%
25	35	Electricity, gaz, steam and air conditioning activities	0.91%

Table 4: Share of R&D spending by 2-digit industry (2017), top 25 industries, Denmark

Rank	NACE Rev 2	Description	Share R&D spending
1	21	Pharmaceuticals	26.16%
2	72	Scientific R&D	12.31%
3	28	Manufacture of machinery and equipment n.e.c.	10.75%
4	26	Manufacture of computer, electronic and optical products	9.47%
5	64	Financial services	6.72%
6	20	Chemicals	5.87%
7	62	Computer programming, consultancy and related activities	5.87%
8	66	Support to financial and insurance services	4.34%
9	46	Wholesale	3.81%
10	71	Architectural and engineering services; technical testing and analysis	3.07%
11	65	Insurance and pension funds	2.24%
12	10	Food	1.45%
13	32	Other manufacturing	1.04%
14	27	Manufacture of electrical equipment	0.97%
15	94	Activities of membership organizations	0.68%
16	58	Publishing activities	0.58%
17	70	Activities of head offices; management consultancy activities	0.57%
18	23	Manufacture of other non-metallic mineral products	0.45%
19	63	Information service activities	0.37%
20	35	Electricity, gaz, steam and air conditioning activities	0.33%
21	22	Rubber and plastic	0.32%
22	61	Telecommunications	0.29%
23	25	Fabricated metal products (except machinery and equipment)	0.28%
24	29	Manufacture of motor vehicles, trailers and semi-trailers	0.23%
25	13	Textiles	0.12%

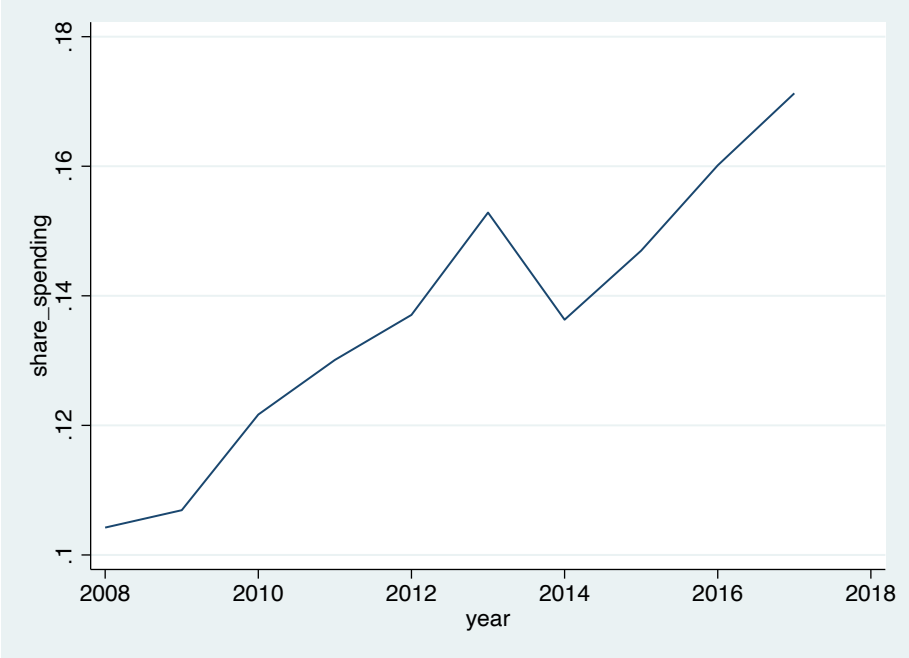
4 Dynamic evolution at the sector level

The previous section showed how the respective countries had built comparative advantages for innovation in different sectors. This section looks at the relative evolution of the shares of these top sectors in each country.

4.1 Norway

As shown in table 3, the top innovative sector in Norway is the "Computer programming, consultancy and related activities" (code 62). The relative share of this industry has clearly been increasing from 10.4% to 17.1% between 2008 and 2017.

Figure 3: Relative share of sector 62 in total R&D expenses, Norway, 2008-2017



Another industry that has grown relatively is the "Publishing activities" industry (NACE 58) where the share increased from increased from 6.8% to 8.6%. This activity involves computer games and also software design and publication.

On the other hand the share of other top sectors such as "Architectural and engineering services; technical testing and analysis" (NACE 71) remained stable around 10%, or declined from 10.8% to 6.3% in the case of "Manufacture of computer, electronic and optical products" (NACE 26).

Figure 4: Relative share of sector 58 in total R&D expenses, Norway, 2008-2017

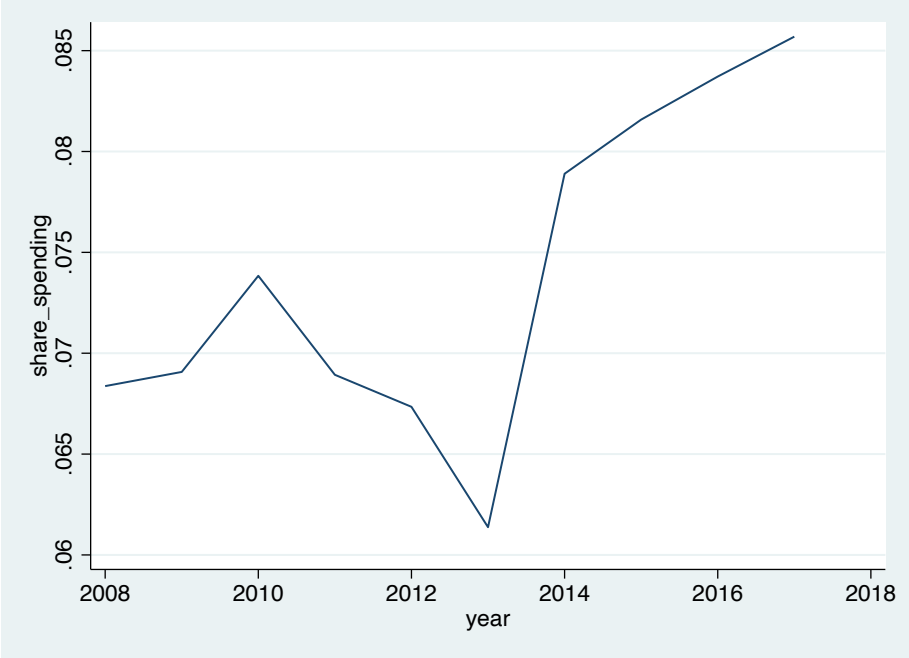


Figure 5: Relative share of sector 71 in total R&D expenses, Norway, 2008-2017

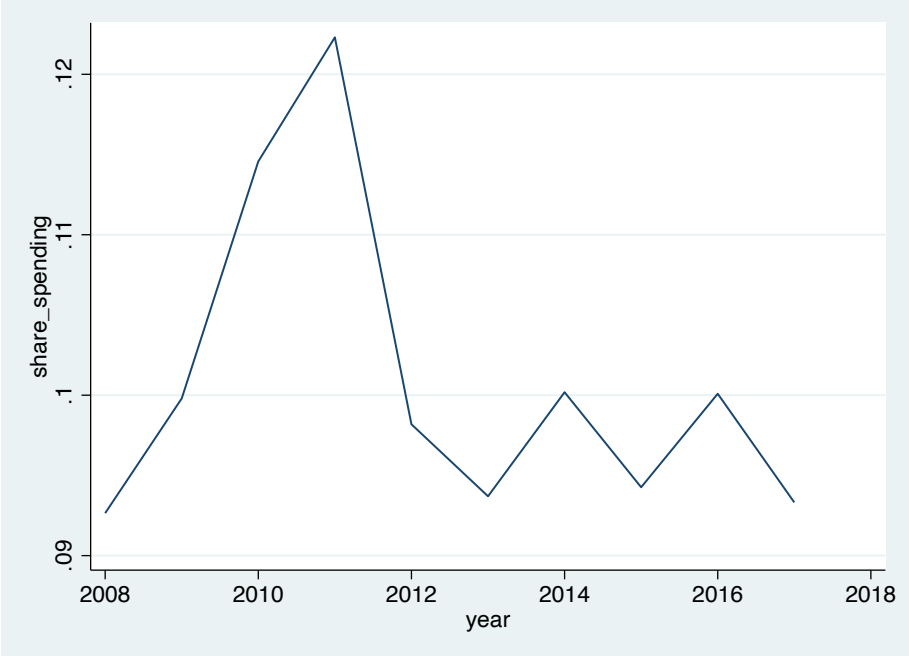
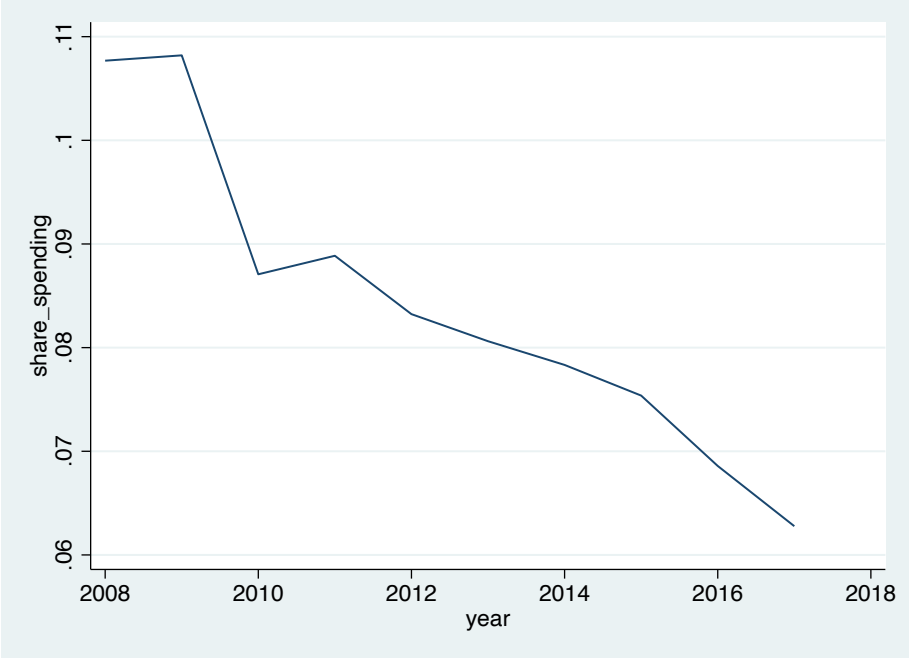


Figure 6: Relative share of sector 26 in total R&D expenses, Norway, 2008-2017



4.2 Denmark

Compared to Norway, the innovation specialization patterns have been mostly increasingly focused in the manufacturing industry, in particular pharmaceuticals and machinery, while the shares in the top service sectors have been either stable or declining.

As can be seen from figure 7, the share of pharmaceuticals (NACE 21) has been increasing from 19.2% to 28.4%, while the share of machinery and equipment (NACE 28) slightly from 8% to 10%. The share of "Scientific R&D " (NACE 72) remained quite stable around 12%. Among the other top sectors, the share of "Manufacture of computer, electronic and optical products" (NACE 26) had ups and downs but remained remained relatively stable around 9%, while the share of "Computer programming, consultancy and related activities" (NACE 62) went down significantly from 11% to 6.3%.

Figure 7: Relative share of sector 21 in total R&D expenses, Denmark, 2008-2017

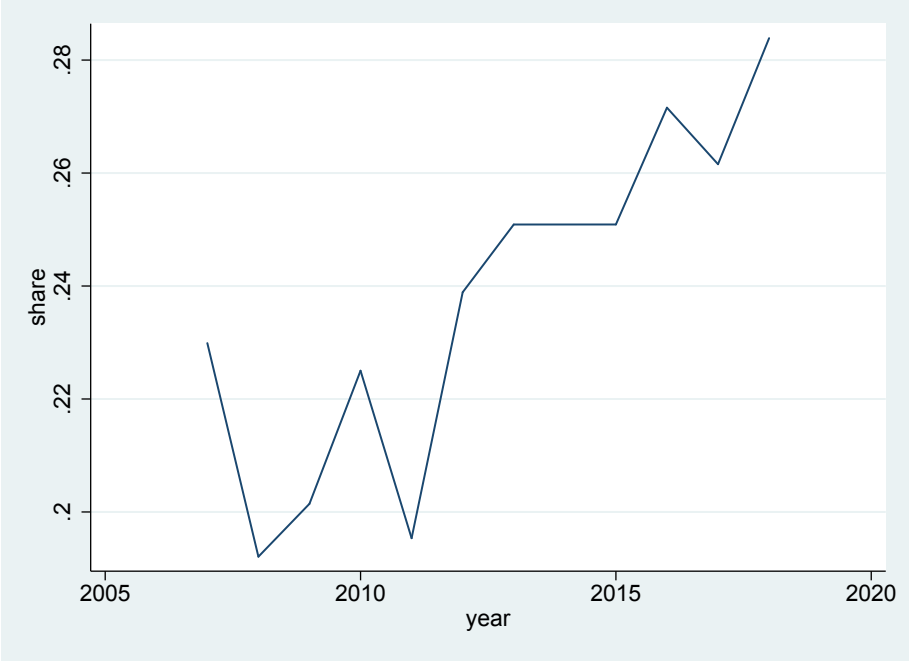


Figure 8: Relative share of sector 28 in total R&D expenses, Denmark, 2008-2017

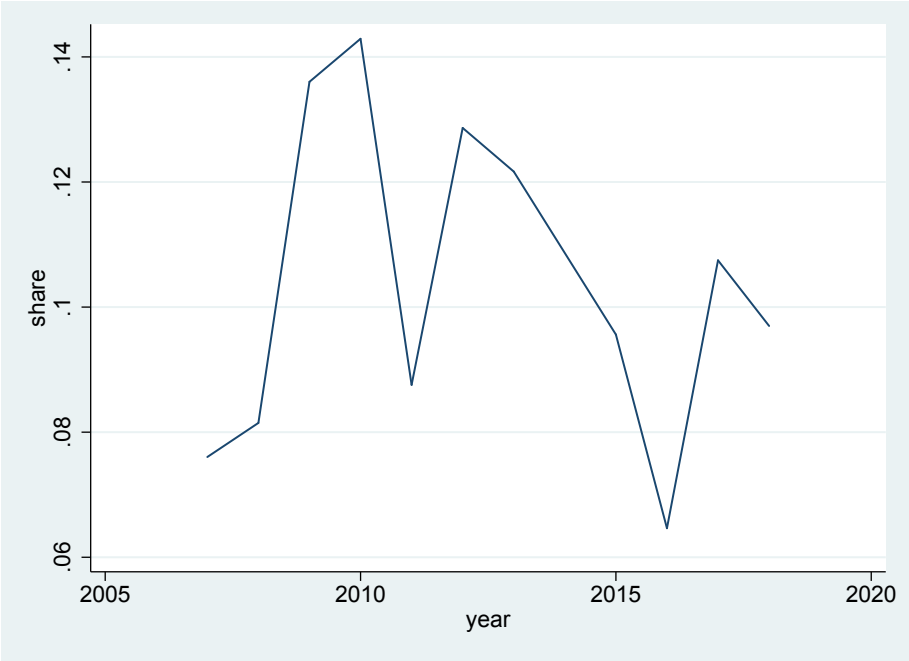


Figure 9: Relative share of sector 72 in total R&D expenses, Denmark, 2008-2017

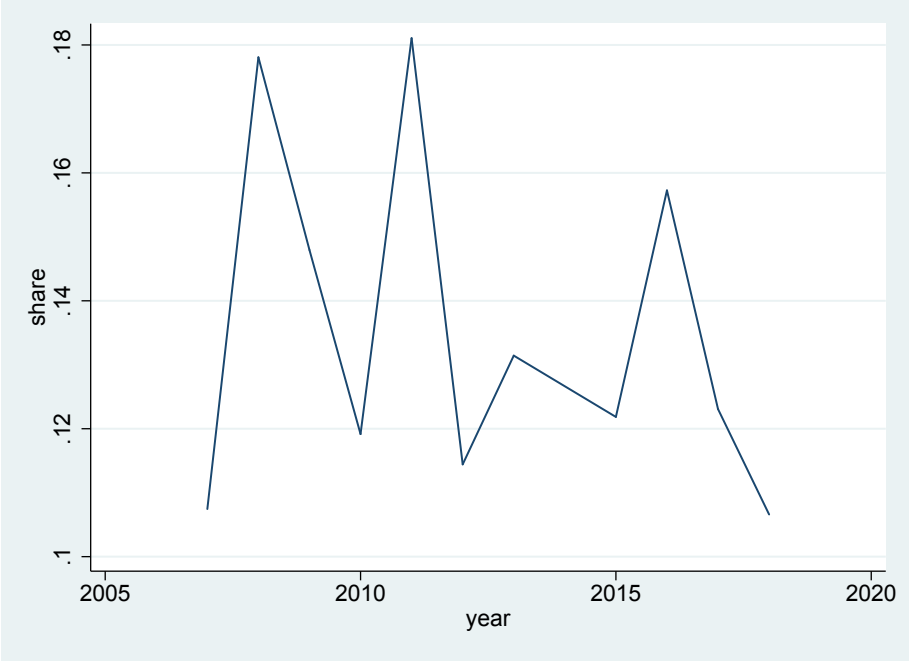


Figure 10: Relative share of sector 26 in total R&D expenses, Denmark, 2008-2017

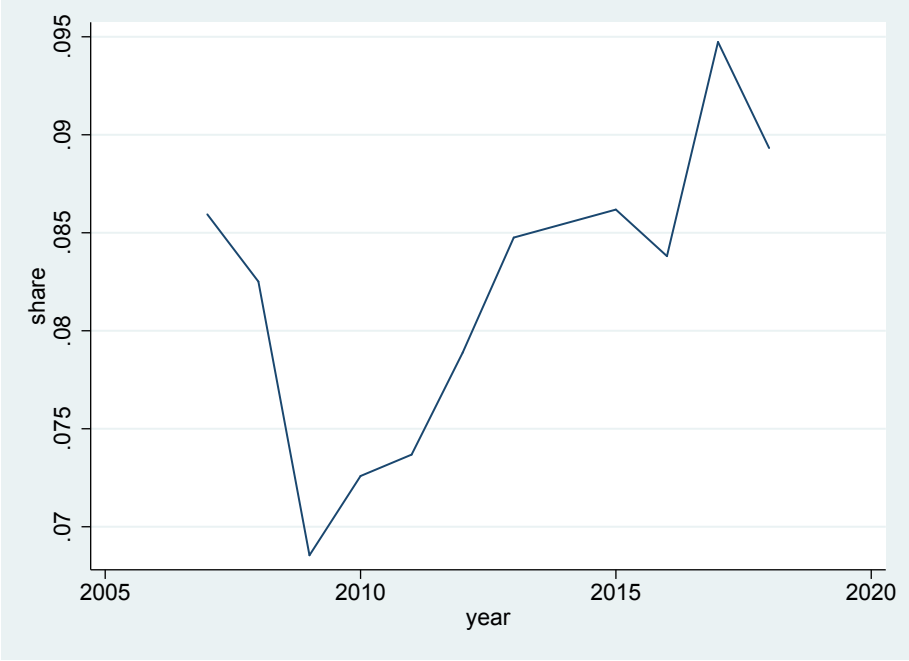
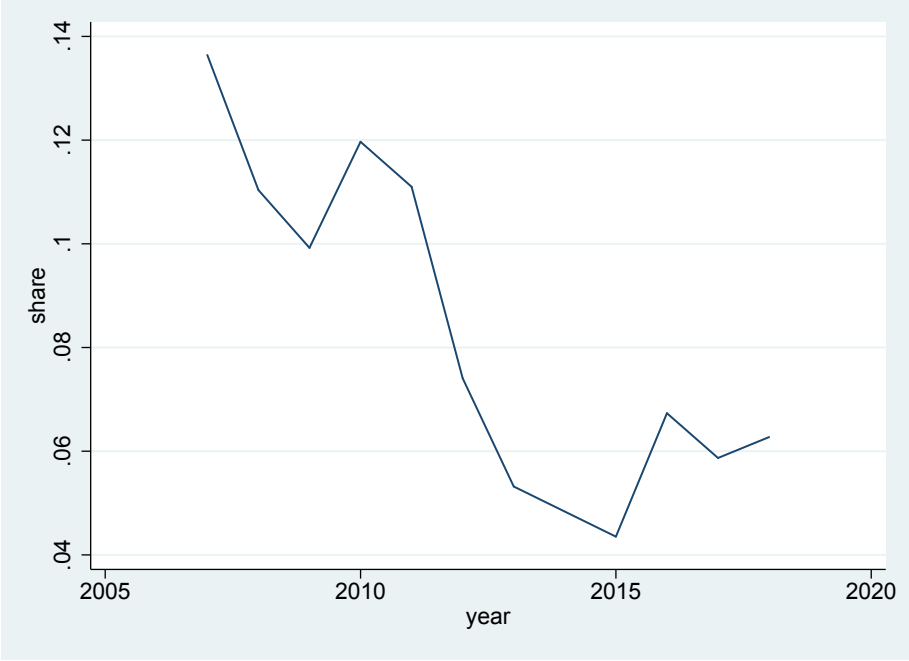


Figure 11: Relative share of sector 62 in total R&D expenses, Denmark, 2008-2017



5 Conclusion

In this paper, I use confidential survey datasets from three Scandinavian countries to analyze the evolution of innovation specialization among countries. I document a clear increase in innovative sectoral specialization, with Denmark increasing specialization in pharmaceuticals and machinery, while Norway getting more focused in the service industry in particular publishing activities and computer programming and consultancy.

I also document differences between the different countries regarding the respective roles of the intensive and extensive margins. Norway appears to display more firms investing in R&D while in Denmark, established R&D investing firms invest more intensively, therefore leading to different dynamics.