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# Private equity and innovation

*Assessing the impact of private equity investments on Scandinavian portfolio companies*

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# Abstract

*We investigate the impact private equity disbursements have on innovation in Scandinavia, using an empirical methodology developed by Kortum and Lerner (2000). Our sample consists of PE disbursements, R&D expenditures and granted patents in Norway, Sweden and Denmark from 1997-2009. Private equity accounted for 12% of patents granted in Scandinavia, while the ratio of private equity to R&D was above 20%. Our findings are contradictory to previous empirical studies and imply that private equity was less potent than R&D in creating innovation from 1997-2009.*

# Preface

This thesis is written as a part of the master's degree in finance at the Norwegian School of Economics (NHH).

Our common fascination for private equity initiated this thesis. The idea to investigate the relationship between private equity and innovation arose through discussions with Argentum Private Equity. Working with this thesis has been a demanding and rewarding experience. We hope that our work will be considered a positive contribution to the field of private equity research in Scandinavia.

There are certain people who deserve recognition for their contribution to this thesis. First and foremost, we would like to thank our supervisor Associate Professor Francisco Santos for valuable feedback throughout the semester. He was always available with advice and was essential in overcoming difficulties that we faced with the dataset. Secondly, we want to thank Argentum Private Equity for providing us with information on the Scandinavian private equity industry. In this regard, a special thanks goes to Ingibjörg Meyer-Myklestad for contributing with ideas and pointing us in the right direction at the beginning of the thesis. Finally, we want to thank Cornelius Mueller, research director and our contact at Invest Europe for clarifications concerning the data.

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# 1. Introduction

There has always been a certain degree of controversy surrounding the private equity (PE) industry. In the US, the asset class attracted attention during the presidential campaigns of Mitt Romney in 2008 and 2012. The co-founder of Bain Capital, one of the most influential PE firms in the US, was criticised for being part of an industry that destroyed companies rather than helping them create value. Romney on the other hand, claimed that PE in fact contributes to economic growth by referring to the number of jobs created by PE backed firms. The opinions have continued to be numerous and divided. Opponents claim that PE firms perform asset stripping and counteracts value creation in their own best interest. While proponents argue they provide needed capital and contribute to new business creation by allocating capital to the best ideas available. Thus, contributing to economic growth.

There are essentially two ways of ensuring economic growth. Either increase the number of inputs going into the production process, or explore new ways to better utilize the existing number of inputs. The latter is referred to as innovation. Moses Abramovitz (1956) was first to acknowledge that an increased output depends on more than simply the input of capital and labour. His findings laid the groundwork for understanding the importance of innovation, which is now recognized as the single most important component of long-term economic growth (Rosenberg, 2004).

This thesis attempts to investigate the impact of PE disbursements on innovation in Norway, Sweden and Denmark.[1] The relationship between PE and innovation was first investigated when Kortum and Lerner published their paper "*Assessing the Contribution of Venture Capital to Innovation*" in 2000. They studied the impact venture capital (VC) had on the number of patented innovations in the US manufacturing sector. As the PE sector has flourished over the last decades, similar studies have been conducted in Europe. In 2009, Popov and Roosenboom replicated the study of Kortum and Lerner (2000) for the European market in their paper "*Does private equity investment spur innovation? Evidence from Europe*".

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[1] PE disbursements refer to all types of investments made by PE funds.

We apply the same methodology as Kortum and Lerner (2000) and Popov and Roosenboom (2009) to assess the relationship between PE and patenting activity in the Scandinavian countries from 1997-2009. In contrast to Kortum and Lerner (2000) we base our main analysis on PE disbursements rather than VC disbursements. Mainly, due to the fact that we had to extrapolate historical values, which turned out to be less accurate for VC than overall PE.

Our analysis contains reduced form regressions on the number of granted patents, research and development (R&D) expenditures and PE disbursements on a sample covering eight industries over 13 years in Norway, Sweden and Denmark. Additionally, we run the regressions on patent applications from 1997-2012 to examine PE disbursements' impact on the willingness to apply for patents. We address the Scandinavian market as a whole and compare PE's contribution to innovation in the countries separately. To our knowledge, this is the first time the Scandinavian PE market has been addressed in this matter.

PE disbursements average 20% of R&D expenditures and account for 12% of granted patents from 1997-2009. PE's contribution to granted patents is lower than the PE/R&D-ratio, implying that PE disbursements are less potent than R&D in creating innovation in Scandinavia. Similar findings are made for patent applications, with PE accounting for 10% of innovation from 1997-2012, while the PE/R&D-ratio averages 21%. In comparison Popov and Roosenboom (2009) found PE to be more potent than R&D in Europe from 1991-2004 as it accounted for 12% of industrial innovation, while averaging 8% of R&D expenditures. Hence, our findings indicate that PE is less potent in Scandinavia than Europe.

The largest impact is found in Norway where PE accounts for 19% of granted patents, while averaging 25% of R&D expenditures. PE seems to be least efficient in Denmark with PE disbursements accounting for 1% of granted patents compared to a PE/R&D-ratio of 21%.

The thesis is structured in the following way: Chapter 2 provides information on PE, a brief overview of the Scandinavian market and insight to previous studies on the topic. Chapter 3 presents the data and the estimations made to facilitate the analysis. Chapter 4 contains the methodology and analysis. Chapter 5 presents the findings, limitations and robustness of the analysis. The final chapter concludes.

# 2. Background

PE is risk capital outside the public markets. The PE market provides capital to unquoted companies including public companies that are de-listed as part of the transaction. PE firms attempt to increase shareholder value in their portfolio companies to achieve capital gains. Investments are made in businesses ranging from early-stage ventures to established companies. Funds investing in early-stage ventures are generalised to VC, while leveraged buyout funds (LBOs) invest in more mature companies (Gilligan and Wright, 2014).

American Research and Development Corporation (ARDC) was founded in 1946 and is commonly viewed as the world's first PE firm. The industry has grown tremendously and several American PE firms now have over $100 billion under management. Although the Scandinavian PE sector is not comparable to its US counterpart in terms of assets under management, it has experienced a substantial growth over the last decades. PE investments by Norwegian, Swedish and Danish PE firms are over 23 times higher today compared to the early 1990s.[2] In 2014, Scandinavian PE firms had a total of €64,311 million under management, which constitutes 11.75% of the European market.

To investigate the impact of PE disbursements on innovation we need to measure the degree of innovation present. Hagedoorn and Cloodt (2003) present R&D input, patent counts, patent citations and counts of new product announcements as indicators of innovative performance. Furthermore, they state that the statistical overlap between the indicators is strong enough for them to be considered suitable on their own. Hence, patent counts are accepted as an appropriate indicator to assess a company's innovative performance.

The relationship between PE and innovation was not systematically scrutinized until Kortum and Lerner (200) examined the influence VC had on patented innovations in the United States between 1965 and 1992. They assume that VC and R&D are the only two sources of innovation, and compare the contribution of VC to the VC/R&D-ratio. Kortum and Lerner (2000) find that VC activity in an industry is associated with significantly higher patenting rates. Their findings suggest that VC may have accounted for as much as 8% of industrial

[2] Combined investments from Scandinavian PE funds averaged €154,193 from 1992-1994 and €3,550,323 from 2012-2014.

innovation, while the VC/R&D-ratio averaged less than 3% from 1983-1992. Thus, VC is more potent than R&D in creating innovation.

Popov and Roosenboom (2009) later applied the same methodology on a cross-country sample to investigate the relationship between PE disbursements and innovation in Europe. In contrast to Kortum and Lerner (2000) they included later stage buy-outs rather than focusing solely on VC disbursements. Their findings suggest that European PE firms are less efficient in spurring innovation than their US counterparts. With PE accounting for 12% of industrial innovation from 1991-2004, while the average PE/R&D-ratio was 8%. The findings of Popov and Roosenboom (2009) are particularly relevant for our analysis as the Scandinavian countries are part of their sample. Furthermore, they operate with total PE values in their analysis, which we also do for our main analysis. Hence, if the European PE market is representative for Scandinavia our results should coincide with Popov and Roosenboom (2009).

Lerner, Sorensen and Strömberg (2011) explore the effect PE has on innovation with focus on LBOs. They explore whether LBO funds pursue short-term profit at the expense of long-term performance to please their investors. Assessing a sample of 472 LBO transactions, they find no such evidence. On the contrary, they find that LBO funds contribute to more innovation in their portfolio companies, just like Kortum and Lerner (2000) showed for VC funds. Although, they do not find evidence of a change in the number of patents, the patents applied for in the years after the LBO transactions are more frequently cited. Hence, the quality of the patents is perceived as improved. Amess, Stiebale and Wright (2015) made similar findings when investigating a sample of 407 buyout deals in the UK. They find that LBOs have a positive effect on the patent stock as well as the quality-adjusted patent stock.

# 3. Dataset

Our dataset contains annual PE disbursements, R&D expenditures and patents for Norway, Sweden and Denmark between 1997-2012. We divide the yearly data into industries in order to get a better picture of how investments in PE and R&D affect patenting activity. Furthermore, we expand the dataset and obtain 15 observations per year.

PE disbursements are collected from Invest Europe's yearbooks.[3] R&D expenditures are obtained from each country's national bureau of statistics.[4] Patenting activity is collected from Eurostat's database.[5] Table 1 presents some descriptive statistics.

| | Patents granted | Patent applications | R&D | PE disbursements | PE/R&D |
|---|---|---|---|---|---|
| **1997** | 2 756 | 3 000 | 9 399 437 | 649 254 | 6.91 % |
| **1998** | 2 680 | 3 205 | 9 949 256 | 572 265 | 5.75 % |
| **1999** | 2 755 | 3 445 | 10 684 658 | 1 595 008 | 14.93 % |
| **2000** | 2 844 | 3 684 | 12 465 596 | 2 429 121 | 19.49 % |
| **2001** | 2 494 | 3 417 | 12 959 056 | 2 989 656 | 23.07 % |
| **2002** | 2 276 | 3 409 | 12 755 227 | 1 313 861 | 10.30 % |
| **2003** | 2 230 | 3 483 | 12 699 985 | 2 022 743 | 15.93 % |
| **2004** | 2 196 | 3 732 | 12 270 195 | 2 569 182 | 20.94 % |
| **2005** | 2 408 | 4 109 | 12 319 688 | 4 474 754 | 36.32 % |
| **2006** | 2 606 | 4 243 | 12 729 450 | 4 545 498 | 35.71 % |
| **2007** | 2 793 | 4 595 | 12 772 546 | 5 401 626 | 42.29 % |
| **2008** | 2 621 | 4 506 | 11 417 763 | 3 751 001 | 32.85 % |
| **2009** | 2 092 | 4 381 | 12 207 542 | 1 946 456 | 15.94 % |
| **2010** | ---- | 4 570 | 12 807 040 | 4 441 400 | 34.68 % |
| **2011** | ---- | 4 724 | 13 078 187 | 4 156 790 | 31.78 % |
| **2012** | ---- | 3 772 | 13 646 631 | 2 807 600 | 20.57 % |
| **Average** | **2 519** | **3 892** | **12 135 141** | **2 854 139** | **23.52 %** |

Table 1: Descriptive statistics for Scandinavia. Yearly patenting activity, R&D expenditures, PE disbursements and PE/R&D-ratio combined for Norway, Sweden and Denmark from 1997-2012.

[3] All amounts are reported in thousands, and adjusted for inflation with 2009 as a basis year.

[4] All amounts are converted from national currencies to Euros and adjusted for inflation with 2009 as a basis year.

[5] Eurostat do not report granted patents after 2009.

To conduct the analysis, we are dependent on comparable numbers. Originally, the collected data is reported differently. Some values are missing, while others are reported in ways that are not comparable. We construct a framework to convert the collected data and make it applicable for the analysis.

Invest Europe is an institution that gathers detailed information from all the national venture capital associations and presents it on an annual basis. They report PE disbursements according to a proprietary industry split, while R&D expenditures and patents are reported according to NACE.[6] Our main concern is to align these two classifications in a way that allows for comparison of our data. We undertake several adjustments to the data to facilitate the analysis. In the following section, we explain our methodology and the reasoning behind the different estimations.

## 3.1 Private equity disbursements

Invest Europe reports numbers on fundraising, investments, divestments and geographic trends for all European countries. The data relevant for our analysis are called Market Statistics and are based on the location of the portfolio company that receives PE disbursements. Market Statistics were first introduced when Invest Europe changed reporting standards in 2007. Prior to this they only reported data based on the location of the PE fund, or so called Industry Statistics.

Popov and Roosenboom (2009) also utilize the Invest Europe yearbooks. In contrast to our paper they conduct their analysis based on Industry Statistics rather than Market Statistics. They argue that the two amounts will be quite similar if all types of PE disbursements are included. However, when considering this approach, we discovered that the numbers did in fact deviate substantially. In 2007, Market Statistics were €480,013, €75,029 and €500,974 higher than Industry Statistics for Norway, Sweden and Denmark respectively (Appendix I). On the basis of this discovery, we decided to apply the accurate Market Statistics from 2007-2012 and extrapolate the values prior to this year. It should be noted that Popov and

6 Nomenclature générale des activités économiques dans les Communautés Européennes (NACE) is a statistical classification of economic activities in the European community that facilitate for comparison of a variety of economic activities (Ec.europa.eu, 2016).

Roosenboom (2009) only had two years of applicable Market Statistics when they conducted their analysis in 2009. Hence, they did not have a valid alternative to using Industry Statistics as two years of observations are not enough to estimate historical investments. We argue that eight years gives us sufficient insight to extrapolate values prior to 2007.

### 3.1.1 Estimation of Market Statistics

Market Statistics consists of investments made in national portfolio companies by domestic and foreign PE funds. Domestic investments are reported for every year in our sample, while investments made by foreign PE first started in 2007. To exemplify, in 2007 Invest Europe reports Market Statistics of €1,178,505 in Norway. It is further reported that €567,390 originates from domestic PE funds, while €611,115 comes from foreign PE funds. In 2006, only domestic investments of €426,731 is reported.

We have applicable data starting from 2007, but only a share of the total Market Statistics prior to this year. Thus, we need to estimate investments made by foreign PE funds in Scandinavian portfolio companies prior to 2007 on the basis of domestic investments. PE firms are best positioned to exploit opportunities available in their home country. Thus, we argue that domestic investments are good indicators of how attractive a market is to foreign investors. It is important to note that this methodology was only applied when we did not have accurate Market Statistics available. For the values after 2007, accurate values are applied.

Invest Europe started reporting main cross-border investments when they introduced Market Statistics in 2007. Most of the foreign PE investments coming into a country originate from PE funds in the same two or three countries. Once more we use Market Statistics in Norway to exemplify. Of the €611,115 Norwegian companies received from foreign PE funds this year, €464,063 and €22,444 came from UK and Swedish funds respectively. If we include domestic investments of €567,390 these three countries accounted for 89% of total Market Statistics in Norway in 2007. Thus, a large share of the Market Statistics can be explained from investments made by domestic PE funds and the inflow from foreign funds in the countries that appear to invest the most. Similar findings are made for the years following 2007.

In order to estimate Market Statistics prior to 2007, we compute a multiple that can be applied to domestic investments. To calculate this multiple, we collect investments made in Norwegian, Swedish and Danish portfolio companies by foreign PE funds. We proceed with the two or three countries that invest the most and compare the investments to domestic investments each year. We then consider the amount that is not yet explained by the largest investing countries, but is needed to make up the total Market Statistics. These investments are referred to as “Rest of the World”. Finally, we compute an average of the investments made by the largest investing countries and “Rest of the world” as a percentage of domestic investments. Combined, these ratios make up the multiple that we apply to domestic investments prior to 2007.

We utilize the calculations for the Norwegian multiple as an example. First, we examine how Swedish and UK funds have invested in Norwegian portfolio companies from 2007-2014. Second, we compare the investments to domestic investments made by Norwegian PE funds in the same year. Third, we withdraw the Swedish and UK investments from the total Market Statistics to discover how much stems from “Rest of the world”. Finally, we compute averages of Swedish, UK and “Rest of the world” investments as a percentage of domestic Norwegian investments between 2007-2014 and combine them to create the multiple (Table 2). We utilize the multiple to estimate Market Statistics before 2007 on the basis of Norwegian domestic investments.

Swedish and UK funds are the largest investors in Norwegian portfolio companies from 2007-2014. They average 20.45% and 50.12% of domestic Norwegian investments respectively. The remaining amount originates from “Rest of the world” and accounts for 7.44% of domestic investments over the same period. To estimate the foreign inflow before 2007, we add these percentages to the domestic investments and apply a multiple of 1.7801 (Table 2).

| Norway | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|
| **Market Statistics** | **1 178 504** | **1 124 709** | **709 223** | **1 886 733** | **905 065** | **966 689** | **1 680 988** | **2 208 987** |
| **Domestic investments** | **567 390** | **656 668** | **596 468** | **809 915** | **639 136** | **733 033** | **752 941** | **1 124 137** |
| Swedish investment | 22 444 | 149 680 | 58 967 | 388 492 | 73 744 | 85 206 | 329 461 | 135 518 |
| % Swedish investment by domestic investments | 4 % | 23 % | 10 % | 48 % | 12 % | 12 % | 44 % | 12 % |
| **Average** | **20.45 %** | | | | | | | |
| UK investment | 464 063 | 288 673 | 47 588 | 673 670 | 187 844 | 88 634 | 532 878 | 807 204 |
| % UK investment by domestic investments | 82 % | 44 % | 8 % | 83 % | 29 % | 12 % | 71 % | 72 % |
| **Average** | **50.12 %** | | | | | | | |
| Investment Rest of the world | 124 607 | 29 688 | 6 200 | 14 657 | 4 342 | 59 816 | 65 707 | 142 129 |
| Investment Rest of the world by domestic investments | 22 % | 5 % | 1 % | 2 % | 1 % | 8 % | 9 % | 13 % |
| **Average** | **7.44 %** | | | | | | | |
| **Applied multiple** | **1.7801** | | | | | | | |

Table 2: Calculation of Norwegian multiple. Yearly investment in Norwegian portfolio companies relative to domestic Norwegian investment from 2007-2014.

Norwegian, UK and Danish funds are the largest investors in Swedish portfolio companies from 2007-2014. They average 2.54%, 26.95% and 2.60% of domestic Swedish investments respectively. The remaining amount originates from “Rest of the world” and accounts for 8.30% of domestic investments over the same period. To estimate the foreign inflow before 2007, we add these percentages to the domestic investments and apply a multiple of 1.4038 (Table 3).

| Sweden | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|
| **Market Statistics** | **3 085 305** | **2 288 301** | **1 112 09** | **2 766 545** | **3 354 258** | **2 527 281** | **813 87** | **1 421 46** |
| **Domestic investments** | **2 179 688** | **1 975 306** | **860 313** | **2 218 243** | **1 556 676** | **1 796 337** | **662 02** | **1 072 13** |
| Norwegian Investment | 84 922 | 24 160 | 10 822 | 30 046 | 4 360 | 75 767 | 25 904 | 44 842 |
| % Norwegian investment by domestic investments | 3.90 % | 1.22 % | 1.6 % | 1.35 % | 0.28 % | 4.22 % | 3.91 % | 4.18 % |
| **Average** | **2.54 %** | | | | | | | |
| UK investment | 753 247 | 133 629 | 43 653 | 385 446 | 1 602 162 | 475 891 | 52 763 | 154 575 |
| % UK investment by domestic investments | 34.56 % | 6.76 % | 5.07 % | 17.38 % | 102.92 % | 26.49 % | 7.97 % | 14.42 % |
| **Average** | **26.95 %** | | | | | | | |
| Danish investment | 33 775 | 22 574 | 3 947 | 60 473 | 32 345 | 78 468 | 46 072 | 16 006 |
| % Danish investment by domestic investments | 1.55 % | 1.14 % | 0.46 % | 2.73 % | 2.08 % | 4.37 % | 6.96 % | 1.49 % |
| **Average** | **2.60 %** | | | | | | | |
| Investment Rest of the world | 33 672 | 132 633 | 193 358 | 72 337 | 158 715 | 100 818 | 27 114 | 133 902 |
| Investment Rest of the world by domestic investments | 1.54 % | 6.71 % | 22.48 % | 3.26 % | 10.20 % | 5.61 % | 4.10 % | 12.49 % |
| **Average** | **8.30 %** | | | | | | | |
| **Applied multiple** | **1.4038** | | | | | | | |

Table 3: Calculation of Swedish multiple. Yearly investment in Swedish portfolio companies relative to domestic Swedish investment from 2007-2014.

Swedish and UK funds are the largest investors in Danish portfolio companies from 2007-2014. They average 12.8% and 82.54% of domestic Danish investments respectively. The remaining amount originates from "Rest of the world" and accounts for 13.51% of domestic investments over the same period. To estimate the foreign inflow before 2007, we add these percentages to the domestic investments and apply a multiple of 2.0885.

| Denmark | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|
| **Market Statistics** | **1 835 153** | **1 207 400** | **479 041** | **385 65** | **880 586** | **861 573** | **1 868 187** | **1 250 285** |
| **Domestic investments** | **1 175 265** | **419 760** | **391 732** | **241 67** | **279 551** | **426 379** | **1 248 046** | **449 133** |
| Swedish investment | 87 134 | 39 804 | 38 504 | 71 320 | 46 679 | 11 431 | 215 282 | 42 697 |
| % Swedish investment by domestic investments | 7.41 % | 9.48 % | 9.83 % | 29.51 | 16.70 % | 2.68 % | 17.25 % | 9.51 % |
| Average | **12.80 %** | | | | | | | |
| UK investment | 500 717 | 557 443 | 17 788 | 49 089 | 538 049 | 386 666 | 224 263 | 714 019 |
| % UK investment by domestic investments | 43 % | 133 % | 5 % | 20 % | 192 % | 91 % | 18 % | 159 % |
| Average | **82.54%** | | | | | | | |
| Investment Rest of the world | 72 037 | 190 394 | 31 016 | 23 576 | 16 307 | 37 097 | 180 596 | 44 435 |
| Investment Rest of the world by domestic investments | 6.13 % | 45.36 % | 7.92 % | 9.76 % | 5.83 % | 8.70 % | 14.47 % | 9.89 % |
| Average | **13.51 %** | | | | | | | |
| **Applied multiple** | **2.0885** | | | | | | | |

Table 4: Calculation of Danish multiple. Yearly investment in Danish portfolio companies relative to domestic Danish investment from 2007-2014.

We also considered alternative approaches to extrapolate the Market Statistics prior to 2007. To decide on the most suitable approach, we apply the estimation methodologies to the year following 2007 and compare them to the accurate Market Statistics. The approach that deviate the least from the correct numbers is used to extrapolate values prior to 2007.

One approach was to construct a multiple based on foreign investments rather than domestic investments. Instead of computing UK and Swedish funds' investments in Norwegian portfolio companies as a share of domestic Norwegian investments, we considered these amounts as shares of total foreign investments. To exemplify with numbers, we previously mentioned that UK and Swedish PE funds invested €464,063 and €22,444 in Norwegian portfolio companies in 2007. This represents 3.00% and 2.48% of overall foreign investments made by PE funds in the respective countries that year. It would be reasonable to assume the average share of total foreign PE investments going into Norwegian portfolio companies between 2007 and 2014 would reflect the investments made prior to 2007. However, when applying this multiple to the years after 2007 the values deviate more from the actual Market Statistics than the case was for the approach with domestic investments. Table 5 shows the accurate Market Statistics from 2007-2014 and compare the numbers to the estimations resulting from the two approaches. The estimates based on domestic investments are most accurate for all years, except 2009 and 2010. This suggest that domestic investments are better indicators than foreign investments to estimate Market Statistics prior to 2007. The findings support our assumption that domestic firms are best positioned to exploit opportunities in their home country.

| Norway | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|
| **Market Statistics** | 1 178 504 | 1 124 709 | 709 223 | 1 886 733 | 905 065 | 966 689 | 1 680 988 | 2 208 987 |
| **Estimations based on domestic investments** | 1 010 014 | 1 168 937 | 1 061 775 | 1 441 733 | 1 137 728 | 1 304 877 | 1 340 315 | 2 001 082 |
| **Deviation from accurate Market Statistics** | **168 490** | **-44 229** | **-352 552** | **445 000** | **-232 663** | **-338 187** | **340 673** | **207 906** |
| **Estimations based on foreign investments** | 1 731 174 | 1 305 345 | 956 660 | 1 441 786 | 2 086 326 | 1 416 442 | 1 157 667 | 1 658 248 |
| **Deviation from accurate Market Statistics** | **-552 670** | **-180 636** | **-247 437** | **444 948** | **-1 181 261** | **-449 752** | **523 321** | **550 740** |

Table 5: Estimation approaches for Market Statistics. Two approaches for estimating Market Statistics in Norway, and deviations from accurate Market Statistics in 2007-2014. The most accurate method each year is highlighted.

Although our approaches suggest that domestic investments are the most suitable indicators for extrapolating Market Statistics prior to 2007 it should be emphasized that our eight-year sample does not provide a perfect picture of historical Market Statistics. Consequently, when applying the multiples to domestic investments after 2007 our results deviate from the accurate Market Statistics. To account for this limitation, we include an individual analysis on a sample starting in 2007. This analysis will have fewer observations, but have the benefit of accurate Market Statistics. Including such an analysis control the robustness of our initial results. If the results are robust we would expect to find similar results with the sample from 2007-2012.

After applying the multiples to estimate historical values we have obtained Market Statistics for Norway, Sweden and Denmark from 1997-2006 (Appendix II). In order to enlarge our sample, we have to allocate the Market Statistics to the industries created by Invest Europe.

### 3.1.2 Distribution of PE disbursements to industries

Invest Europe divides the data in 15 different industries. For the years after 2007 the Market Statistics are already allocated among these industries. However, for the beginning of our sample we do not have an accurate division. We utilize the observations we have between 2007-2014 to allocate our estimated Market Statistics. We use the average distribution for each country and assume that the industries have attracted the same relative amount prior to 2007. Table 6 shows how Market Statistics were divided among the 15 industries, the share going into each industry in 2007 and the average from 2007-2014. Prior to 2007 the estimated Market Statistics are divided between the 15 industries based on the trends from 2007-2014.

| Norway | | | |
|---|---|---|---|
| **Industries** | **2007** | **2007 allocation** | **Average allocation 07-14** |
| Agriculture | 9 521 | 0.81 % | 2.53 % |
| Business & industrial products | 105 815 | 8.98 % | 5.44 % |
| Business & industrial services | 27 016 | 2.29 % | 5.34 % |
| Chemicals & materials | 0 | 0.00 % | 0.35 % |
| Communications | 368 187 | 31.24 % | 10.26 % |
| Computer & consumer electronics | 54 184 | 4.60 % | 14.64 % |
| Construction | 0 | 0.00 % | 1.64 % |
| Consumer goods & retail | 258 848 | 21.96 % | 11.50 % |
| Consumer services | 429 | 0.04 % | 4.25 % |
| Energy & environment | 237 880 | 20.18 % | 28.71 % |
| Financial services | 1 159 | 0.10 % | 3.21 % |
| Life sciences | 57 388 | 4.87 % | 9.55 % |
| Real estate | 4 842 | 0.41 % | 0.27 % |
| Transportation | 16 450 | 1.40 % | 1.86 % |
| Unclassified | 36 787 | 3.12 % | 0.45 % |
| **SUM** | **1 178 504** | **100.00 %** | **100.00 %** |

Table 6: Industry allocation of Market Statistics. Market Statistics allocated to Invest Europe's industries in 2007, and the average allocation from 2007-2014

We considered alternative approaches to allocate Market Statistics to the different industries. Again, we experimented with shifting the focus to the investing countries. Invest Europe provides information on the investments patterns for all European countries and we tried utilizing this for our distribution. We use Norway 2007 as an example, table 2 shows that the Norwegian Market Statistics of €1,178,505 consists of €567,390 from domestic PE funds, €464,063 from UK funds, €22,444 from Swedish funds and €124,607 from "Rest of the World". We collect similar data for the following seven years and compare the investments to the total foreign PE investments made in Norway each year. It shows that Swedish PE funds account for 26%, UK funds account for 65% and funds from "Rest of the world" account for 9% of the foreign investments in Norwegian portfolio companies from 2007-2014. We investigate the effects of allocating the estimated Market Statistics based on these shares. In 2007 the domestic investments of €567,390 was distributed based on the average investment pattern of Norwegian PE funds. Foreign investments of €611,115 was divided with the aforementioned shares and distributed according to the investment patterns of the respective countries.

When comparing the estimated numbers to the actual ones in 2007, it proved more accurate to use the distribution based on average Market Statistics. This was also the case for the following years. Table 7 shows the largest deviation from the actual Market Statistics every year. It is clear that our chosen approach (MS) deviates the least when we apply the two distribution approaches to the numbers between 2007 and 2014.[7] Although allocating the estimated Market Statistics based on the average allocation from 2007-2014 seems quite simplistic, it turned out to be the approach that presented us with the most realistic values when we apply the methodologies to the numbers after 2007.

| Country | Norway | | Sweden | | Denmark | |
|---|---|---|---|---|---|---|
| Method | MS average | IS Average | MS average | IS Average | MS average | IS Average |
| 2007 | 34 153 | --- | 22 980 | --- | 23 679 | --- |
| 2008 | 37 070 | --- | --- | 352 709 | 93 091 | --- |
| 2009 | 11 061 | --- | --- | 39 028 | --- | 18 524 |
| 2010 | --- | 131 791 | 282 471 | --- | --- | 299 420 |
| 2011 | --- | 92 774 | --- | 267 599 | --- | 75 175 |
| 2012 | --- | 80 134 | 114 046 | --- | --- | 195 660 |
| 2013 | --- | 123 975 | --- | 31 580 | 303 883 | --- |
| 2014 | 153 130 | --- | 121 027 | --- | --- | 217 246 |
| SUM | 235 414 | 428 675 | 540 523 | 690 917 | 420 653 | 806 024 |

Table 7: Allocation approaches for Market Statistics. Yearly difference in absolute deviation from Market Statistics between the two methods considered in allocating to industries. No value implies that this method is the most accurate for a given year.

[7] The preferred approach deviates €193,261, €150,394 and €385,371 less than the alternative for Norway, Sweden and Denmark respectively.

## 3.2 Research and development expenditures

We extract the R&D expenditures from the national statistics bureaus. Two different classifications are used to categorize the economic activities. Prior to 2007 the R&D expenditures are reported according to NACE 1.1, while NACE 2.0 is used after 2007. Invest Europe bases its industry classification on NACE 2.0 (Sectorial Classification, 2007). A correspondence table created by Eurostat is used to allocate NACE 1.1 into suitable NACE 2.0 classes (Correspondence table NACE Rev. 1.1 - NACE Rev. 2, 2008). In the cases where one NACE 1.1 class becomes several NACE 2.0 classes, we apply a percentage based on how many subclasses that feature in each NACE 2.0 class (Appendix III). In 2007, values are reported according to both classifications. We utilize this overlapping year to control that the data has been converted as accurate as possible.

To conduct our analysis, we need PE disbursements, R&D expenditures and patents to be reported similarly. As Invest Europe does not give a finer split of their 15 industries, we need to convert the R&D expenditures from NACE 2.0 to Invest Europe's proprietary industry split. We develop a distribution system based on Eurostat's own metadata (Ec.europa.eu, 2016), and a sectorial classification form we received from Invest Europe (Sectorial Classification, 2007). For the matching process to be as accurate as possible we operate with the entire 4-digit codes from the NACE 2.0 classification. In the cases where one NACE 2.0 class falls completely into one Invest Europe industry, the transmission is made directly. However, if a class is divided between several different industries we assign a percentage to the respective industries involved. The share is based on the number of existing subclasses and how many observations we make of that specific class in each of Invest Europe's industries. This allows us to divide the R&D expenditures between multiple Invest Europe industries when it is necessary. To exemplify, the NACE 2.0 class *"C10 - Manufacture of food products"* falls entirely under *"Consumer goods and retail"*, while *"C31 – Manufacture of furniture"* is allocated with ¼ to *"Business and industrial products"* and ¾ to *"Consumer goods and retail"*. The result is a comprehensive distribution system that accounts for the number of observations and splits up the clusters before allocating them appropriately (Appendix IV).

Four caveats are in place for the R&D expenditures. Firstly, certain values prior to 2007 are reported on a semi-annual basis in Norway and Sweden. In order to obtain a complete dataset we use an average of the previous and following year to estimate the missing values.

Secondly, there are differences in both the composition and completeness of the data. Especially the clustering of NACE 1.1 classes varies a lot. Consequently, we alter our correspondence table and make different trade-offs in each country. In addition, some of the clusters after 2007 have to be rearranged in order to fit our distribution system. We utilize the numbers prior to 2007 to calculate average shares, which we apply to split up the existing NACE 2.0 classes. To exemplify, *"01-03 Agriculture, forestry and fishing"* and *"04-09 Mining and quarrying"* fall in different Invest Europe industries but are classified together in NACE 2.0. Prior to 2007 these classes were reported separately, allowing us to compute the average share each class previously has accounted for and split the clusters in a way that is more suitable for our distribution system.

Thirdly, our distribution system is based on the assumption that each subclass represents an equal share of the parent class in NACE 2.0. An example will help clarify this concern. It was previously mentioned how the parent class *"C31 – Manufacture of furniture"* is divided in two different Invest Europe industries, with ¼ and ¾. This is based on the observation of four subclasses, appearing in two different industries. In this case, *"31.01 - Manufacture of office and shop furniture"* belongs to *"Business and industrial products"*, while the other three subclasses belong to *"Consumer goods and retail"*. However, it is not given that the subclasses represents equal parts of the overall amount. On the contrary, the subclasses are likely to constitute different amounts. This could lead to some values being overestimated at the expense of others, but as there is no method to determine the actual share that belong to each subclass, we continue with this assumption.

Fourthly, the subdivision of industries presented by Statistics Denmark is not nearly as thorough as for Norway or Sweden. The overall R&D expenditures are only divided into a few large clusters and it is not possible to relocate the amounts to Invest Europe industries. We include a second source of information with a better division to be able to allocate the numbers. Eurostat presents a very thorough split from 2009-2012. Hence, we have four overlapping years from the two datasets. As the overall amounts for the four years are equal, we design a distribution system that we later apply to allocate the remaining years presented by Statistics Denmark.

## 3.3 Patents

Eurostat reports patents from two different sources. The United States Patent and Trademark Office (USPTO) gives information on patents granted, while the European Patent Office (EPO) provides patent applications. Granting patents is a time consuming process and reported with at least five years lag. Thus, it is not possible obtain data later than 2009. Patent applications are reported until 2012 and extend our sample with three years. Furthermore, the patent applications leaves us with six years (2007-2012) where we do not have to rely on our estimated Market Statistics, but can apply the accurate values and industry distribution.

Eurostat reports both types of patents according to NACE 2.0. The patents are divided into 27 different NACE 2.0 classes. In order to compare the patents to the industries created by Invest Europe we utilize the distribution system that we developed for the R&D expenditures (Appendix IV).

Five of the 15 Invest Europe industries are left without any patents. As a result, we remove *"Agriculture"*, *"Business and industrial services"*, *"Consumer services"*, *"Financial services"* and *"Real estate"* from our sample. It is mainly service industries that are left out. Naturally, these industries do not have any products to patent. It should be noted that they attract quite substantial amounts of PE disbursements and by excluding them we might overestimate the effect PE has on innovation. Additionally, we leave out the sector "Unclassified" as it is not clear what it consists of. This leaves us with nine overlapping industries with values for PE disbursements, R&D expenditures and patents.

The final dataset includes values for Norway, Sweden and Denmark over a period of 13 years for patents granted (1997-2009) and 16 years in the case of patent applications (1997-2012). We have 117 and 144 observations covering nine industries, for patents granted and patent applications respectively. In addition, we conduct a separate analysis on a smaller sample with patent applications and accurate Market Statistics distribution.

## 3.4 Descriptive statistics

In this section we give a descriptive overview of our data. Patenting activity, R&D expenditures and PE disbursements are presented for every industry in Norway, Sweden and Denmark. We also include the ratio PE over R&D to give an indication of the relative relationship between the two sources of innovation. This is something we will return to when evaluating the impact PE disbursements have on innovation.

| Norway | Patents granted | Patent applications | R&D | PE disbursements | PE/R&D |
|---|---|---|---|---|---|
| Business & industrial products | 143 | 183 | 348 198 | 38 210 | 10.97 % |
| Chemicals & materials | 26 | 42 | 110 072 | 2 113 | 1.92 % |
| Communications | 10 | 10 | 334 010 | 84 680 | 25.35 % |
| Computer & consumer electronics | 53 | 50 | 248 925 | 113 057 | 45.42 % |
| Construction | 6 | 13 | 38 281 | 10 171 | 26.57 % |
| Consumer goods & retail | 34 | 51 | 119 285 | 89 298 | 74.86 % |
| Energy & environment | 1 | 2 | 155 627 | 193 229 | 124.16 % |
| Life sciences | 37 | 53 | 101 160 | 75 619 | 74.75 % |
| Transportation | 18 | 22 | 92 899 | 16 524 | 17.79 % |
| **SUM** | **327** | **426** | **1 548 458** | **622 903** | **40.23 %** |

Table 8: Descriptive statistics for Norway. Yearly average of patenting activity, R&D expenditures, PE disbursements and PE/R&D-ratio for Norway from 1997-2012

As shown in table 8, "*Business & industrial products*" is the most active industry in regards of patenting in Norway. Nearly half of the patents belong to this industry. The other extreme is "*Energy & Environment*", with virtually no patenting activity. This is something we find surprising as we would assume patenting activity in the Norwegian offshore sector would be registered in this industry.

PE disbursements are large relative to R&D expenditures and accounts for 40.23% on average from 1997-2012. This number is mainly driven by *"Energy & environment"* and is fairly large in comparison to similar studies.[8] An explanation for this could be that these

[8] Kortum and Lerner (2000) reports a VC/R&D ratio of 3% in the US from 1983-1991 and Popov and Roosenboom (2009) reports a PE/R&D-ratio of 8% in Europe between 1991 and 2004.

studies are conducted with an older data sample and PE has experienced an exponential growth in Scandinavia over the last decades.

| Sweden | Patents granted | Patent applications | R&D expenditures | PE disbursements | PE/R&D |
|---|---|---|---|---|---|
| Business & industrial products | 663 | 1 001 | 1 719 716 | 402 489 | 23.40 % |
| Chemicals & materials | 57 | 92 | 201 016 | 83 348 | 41.46 % |
| Communications | 66 | 87 | 511 530 | 150 459 | 29.41 % |
| Computer & consumer electronics | 332 | 443 | 1 094 820 | 212 830 | 19.44 % |
| Construction | 36 | 61 | 79 077 | 82 980 | 104.94 % |
| Consumer goods & retail | 162 | 261 | 261 406 | 215 770 | 82.54 % |
| Energy & environment | 1 | 2 | 45 527 | 93 618 | 205.63 % |
| Life sciences | 192 | 273 | 1 850 537 | 361 584 | 19.54 % |
| Transportation | 96 | 171 | 1 681 130 | 20 625 | 1.23 % |
| **SUM** | **1 605** | **2 392** | **7 444 758** | **1 623 701** | **21.81 %** |

Table 9: Descriptive statistics for Sweden. Yearly average of patenting activity, R&D expenditures, PE disbursements and PE/R&D-ratio for Sweden from 1997-2012.

Table 9 shows similar trends in the Swedish market. More than one third of the patenting activity stems from "*Business & industrial products*", while "*Energy & environment*" barely has any patents. In "*Energy & environment*" PE disbursements and R&D expenditures are lower compared to total investments, and the low count of patents seems more logical than in Norway. However, we still consider the patent count as surprisingly low.

The average PE/R&D-ratio in Sweden is 21.81%. Although R&D expenditures are relatively large in comparison to PE disbursements, the ratio is more in line with the data applied by Kortum and Lerner (2000) and Popov and Roosenboom (2009). Again, we discover that certain industries contribute to this high number. Particularly "*Energy & environment*" and "*Construction*" show a substantially higher PE/R&D-ratio than the average of 21.81%.

| Denmark | Patents granted | Patents applied | R&D expenditures | PE disbursements | PE/R&D |
|---|---|---|---|---|---|
| Business & industrial products | 199 | 417 | 703 514 | 83 097 | 11.81 % |
| Chemicals & materials | 34 | 63 | 187 562 | 10 695 | 5.70 % |
| Communications | 15 | 20 | 275 118 | 48 342 | 17.57 % |
| Computer & consumer electronics | 77 | 104 | 520 204 | 133 052 | 25.58 % |
| Construction | 13 | 44 | 28 663 | 47 799 | 166.76 % |
| Consumer goods & retail | 82 | 169 | 238 882 | 89 328 | 37.39 % |
| Energy & environment | 2 | 3 | 33 812 | 21 400 | 63.29 % |
| Life sciences | 153 | 232 | 1 128 382 | 138 936 | 12.31 % |
| Transportation | 12 | 22 | 25 788 | 34 886 | 135.28 % |
| **SUM** | **587** | **1 074** | **3 141 925** | **607 535** | **19.34 %** |

Table 10: Descriptive statistics for Denmark. Yearly average of patenting activity, R&D expenditures, PE disbursements and PE/R&D-ratio for Denmark from 1997-2012.

From table 10 we see that patenting activity in Denmark is fairly similar to the other two Scandinavian countries. "*Business & industrial products*" contains the largest number of patents, while "*Energy & environment*" has very few yearly patents. "*Construction*" and "*Transportation*" stands out as the two most PE intensive industries, with "*Energy & environment*" still being quite large. The PE/R&D-ratio is 19.34%, and the lowest of the Scandinavian countries.

# 4. Methodology

In order to evaluate the impact PE disbursements have on innovation we conduct a series of reduced form regressions. We start by analysing a production function that assess patenting activity as a function of R&D expenditures and PE disbursements. Following this, we conduct an analysis under the assumption that PE and R&D are perfect substitutes as means of creating innovation analysing a linearized equation. The methodology follows the original work of Kortum and Lerner (2000) and the assumptions are explained and justified as we carry out the analysis. A more thorough interpretation of the results is presented in the next chapter.

It is important to emphasize that the model is based on certain simplifications. Patenting activity depends on more than PE disbursements and R&D expenditures, for example technological bursts or the behaviour of the patentee. We also assume that PE and R&D are substitutes in terms of creating patenting activity. However, R&D expenditures are likely to include some research financed by PE, making it less likely for us to find the isolated impact PE disbursements have on patenting conditional on R&D expenditures.

## 4.1 The patent production function

A patent production function is the starting point for the analysis. It provides a first look at the relationship between patenting activity, R&D expenditures and PE disbursements. This production function is later customized to assess the contribution of PE to innovation.

$$P_{it} = (RD_{it}^{\rho} + bPE_{it}^{\rho})^{\alpha/\rho} u_{it} \qquad (1)$$

Patenting (P) is a function of privately funded industrial R&D expenditures (RD) and PE disbursements (PE). The error term ($u$) captures the effects that are not explained by the model, such as the arrival of new technological opportunities and the propensity to patent. All variables are indexed by industry (i) and year (t). The parameter $b$ captures the role of PE in the function. Our main focus is on this parameter as any $b > 0$ suggest that PE has a positive impact on innovation. If $b = 0$ the patent production function is reduced to the standard form with R&D expenditures as its only input. The parameter ($\alpha$) measures the percentage change in patenting brought about by a 1% change in both R&D and PE. The parameter ($\rho$) measures the degree of substitutability between R&D and PE. If $\rho$ = 1, the inputs are perfect substitutes and the function is reduced to

$$P_{it} = (RD_{it} + bPE_{it})^{\alpha} u_{it} \quad (2)$$

If $\rho$ = 0, the function reduces to a Cobb-Douglas functional form

$$P_{it} = RD_{it}^{\alpha/(1+b)} + PE_{it}^{\alpha b/(1+b)} u_{it} \quad (3)$$

We will discuss the interpretation of the substitution parameter in greater length later in the analysis.

## 4.2 Estimates

To obtain estimates for the parameters in our production function, we start with a non-linear least squares regressions. We continue by linearizing the equation before we alter the dataset as a result of outliers and run the final regressions. The parameters are interpreted and explained as the analysis moves forward.

### 4.2.1 Non-linear least squares

Our first estimates are non-linear least squares of the patent production function. We log equation 1, to obtain equation 4 and run regressions for each country and Scandinavia. The dependent variables are the logarithms of the number of patent applications and patents granted. The two independent variables are the logarithm of R&D expenditures and the logarithm of PE disbursements in the same industry and year. Dummy variables for each industry and year are included as controls. We consider both patent applications and granted patents to see if PE disbursements affect the number of ultimately successful patents, or the willingness to apply.

$$ln\, P_{it}^{g} = \frac{\alpha}{\rho} \ln\left(RD_{it}^{\rho} + bPE_{it}^{\rho}\right) + ln\, u_{it} \quad (4)$$

In order to run the regressions we need the initial ρ-value to be somewhere between zero and one, we experiment with several different values for all the countries. We proceed with the ρ-values that show the best fit for the regression lines. The initial results of the non-linear least squares regressions can be found in table 11.

| | Norway | | Sweden | | Denmark | | Scandinavia | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Applied | Granted | Applied | Granted | Applied | Granted | Applied | Granted |
| Return to scale ($\alpha$) | 0.201<br>(0.180) | 0.582<br>(0.179)*** | 1.085<br>(0.085)*** | 1.111<br>(0.093)*** | 0.798<br>(0.065)*** | 0.667<br>(0.121)*** | 0.926<br>(0.099)*** | 0.946<br>(0.106)*** |
| Substitution parameter ($\rho$) | 0.209<br>(0.153) | 0.479<br>(0.128)*** | 0.164<br>(0.326) | 0.100<br>(0.188) | 0.000<br>(0.000) | 0.068<br>(0.145) | 0.643<br>(0.916) | 0.982<br>(0.474)** |
| Private Equity parameter (b) | -0.664<br>(0.201)*** | -0.601<br>(0.075)*** | 0.102<br>(0.120) | 0.075<br>(0.115) | -0.000<br>(0.000) | -0.091<br>(0.178) | -0.160<br>(0.128) | -0.366<br>(0.106)*** |
| $R^2$ | 0.88 | 0.88 | 0.96 | 0.96 | 0.95 | 0.84 | 0.97 | 0.97 |
| $N$ | 144 | 117 | 144 | 117 | 144 | 117 | 144 | 117 |

*Note: Standard errors in parentheses. Dependent variable is the logarithm of the number of patents, applied or granted. Year and industry dummy variables are included in all regressions but not presented in the table. *** denotes significance at the 1%, ** at the 5% and * at the 10% level*

Table 11: Unconstrained non-linear least squares regressions. Non-linear least squares regressions analysis on the patent production function. Unconstrained case for Norway, Sweden, Denmark and Scandinavia.

First, we want to address the role of PE ($b$). The three coefficients that are significantly different from zero show a negative relationship between PE disbursements and innovation. This suggests that PE has a negative impact on patenting activity. However, these results are merely first estimates of PE's contribution to innovation and should be taken with a degree of caution. We will rather focus on the substitution parameter ($\rho$). Without any constraints in our regressions, we can estimate to what extent PE disbursements and R&D expenditures function as substitutes, as means of creating innovation. Granted patents in Norway and Scandinavia are the only two regressions that are significantly different from zero in this regard. For these two regressions, a likelihood ratio test also rejects the extreme case that $\rho = 0$ (at 1%-level). This implies that there is a certain degree of substitution between PE disbursements and R&D expenditures in creating innovation in Norway and Scandinavia.

Kortum and Lerner (2000) continue their analysis with the assumption that $\rho = 1$. To further investigate the role of ρ in our sample we take the natural logarithm of equation 2 and find equation 5

$$ln\ P_{it} = \alpha ln\ (RD_{it} + bPE_{it})\ + ln\ u_{it} \qquad (5)$$

We run non-linear least square regressions on the extreme case where PE disbursements and R&D expenditures are perfect substitutes. The results are shown in table 12.

| | Norway | | Sweden | | Denmark | | Scandinavia | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Applied | Granted | Applied | Granted | Applied | Granted | Applied | Granted |
| Return to scale ($\alpha$) | 0.149 (0.176) | 0.679 (0.180)*** | 1.019 (0.072)*** | 0.939 (0.071)*** | 0.840 (0.072)*** | 0.713 (0.114)*** | 0.952 (0.090)*** | 0.948 (0.085)*** |
| Substitution parameter ($\rho$) | 1.000 --- | 1.000 --- | 1.000 --- | 1.000 --- | 1.000 --- | 1.000 --- | 1.000 --- | 1.000 --- |
| Private Equity parameter (b) | -0.286 (0.239) | -0.359 (0.003)*** | -0.003 (0.089) | -0.260 (0.052)*** | 0.361 (0.260) | 0.154 (0.289) | -0.111 (0.116) | -0.362 (0.056)*** |
| $R^2$ | 0.87 | 0.87 | 0.96 | 0.96 | 0.95 | 0.83 | 0.97 | 0.97 |
| *N* | 144 | 117 | 144 | 117 | 144 | 117 | 144 | 117 |
| *Prob >* $\chi$*^2* | 0.017 | 0.005 | 0.242 | 1.000 | 1.000 | 0.471 | 0.537 | 0.964 |

*Note: Standard errors in parentheses. Dependent variable is the logarithm of the number of patents, applied or granted. Year and industry dummy variables are included. *** denotes significance at the 1%, ** at the 5% and * at the 10% level.*

Table 12: Constrained non-linear least squares regressions. Non-linear least squares regressions analysis on the patent production function. $\rho$ = 1 case for Norway, Sweden, Denmark and Scandinavia.

In the first regressions, only granted patents in Norway and Scandinavia had ρ significantly different from zero. A likelihood ratio test rejects $\rho$ = 1 for Norway and indicates that the substitution parameter is somewhere between the two extremes. We are not able to reject $\rho$ = 1 for Scandinavia.

Although constraining $\rho$ = 1 is only supported in Scandinavia, we apply the restricted equation 5 for the remainder of the analysis in order to follow the methodology of Kortum and Lerner (2000). Hence, ρ is taken as exogenous and we assume that PE disbursements and R&D expenditures are perfect substitutes as means of creating innovation. It is important to note that while this restriction is supported by the findings for Scandinavia, none of the other regressions are able to reject $\rho$ = 0 without also rejecting $\rho$ = 1. This should be kept in mind when evaluating our final results.

### 4.2.2 Estimating a linear specification

Similar to Kortum and Lerner (2000) we continue by estimating *b* through a linear approximation of the patent production function, introduced by Griliches (1986). Griliches argues that a Taylor expansion of the logarithm of the function is reasonable when one input is considerably smaller than the other. Such an approximation has the virtue of providing a conservative result for the effect PE disbursements have on patenting.

Kortum and Lerner's (2000) sample dates back to the 1960s, when PE disbursements constituted a smaller share of R&D expenditures than today. Moreover, they operate with VC disbursements, which is only a share of the total PE disbursements. Consequently, their ratio averages less than 3%. In this case, the VC/R&D-ratio is small enough to justify the use of the Taylor expansion.

The PE/R&D-ratio for the Scandinavian countries from 1997-2012 is considerably larger than the 3% Kortum and Lerner (2000) observe for their sample.[9] It is also larger than the 8% Popov and Roosenboom (2009) report for Europe from 1991-2004. This can partly be explained by the fact that we operate with more recent data.[10] Popov and Roosenboom (2009) also operate with Industry Statistics, which we previously have shown to be smaller than Market Statistics in general. Hence, it will present them with a lower PE/R&D-ratio than if they had applied Market Statistics.

Although PE disbursements accounts for a larger share of R&D expenditures in our sample than for Kortum and Lerner (2000), we continue with the same approximations. We want to emphasize that this is likely to have an effect on our final results.

After linearizing equation 5, we get

$$ln\,P_{it} = \alpha\, lnRD_{it} + \alpha b(\frac{PE_{it}}{RD_{it}}) + ln\,u_{it} \qquad (6)$$

The potency of PE funding ($b$) is now found by dividing the coefficient on PE/RD by the coefficient on RD. Table 13 presents the results from the linearized specification, still with the substitution parameter constrained to one.

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9 The PE/R&D-ratio is 40.23% in Norway, 21.81% in Sweden and 19.34% in Denmark.

10 From 2001-2004 Popov and Roosenboom (2009) found an average PE/R&D-ratio of 10%, 15% and 10% for Norway, Sweden and Denmark respectively.

| | Norway | | Sweden | | Denmark | | Scandinavia | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Applied | Granted | Applied | Granted | Applied | Granted | Applied | Granted |
| R&D Expenditure ($\alpha$) | 0.116 (0.173) | 0.542 (0.183)*** | 1.019 (0.072)*** | 1.009 (0.089)*** | 0.823 (0.068)*** | 0.715 (0.110)*** | 0.923 (0.094)*** | 0.913 (0.102)*** |
| PE/R&D ($\alpha$b) | -0.508 (0.196)** | -1.314 (0.243)*** | -0.003 (0.093) | -0.154 (0.191) | 0.129 (0.054)** | 0.085 (0.080) | -0.210 (0.170) | -0.641 (0.220)*** |
| *PE Parameter (b)* | -4.379 | -2.424 | -0.003 | -0.153 | 0.158 | 0.119 | -0.228 | -0.702 |
| $R^2$ | 0.88 | 0.88 | 0.96 | 0.96 | 0.95 | 0.83 | 0.97 | 0.97 |
| *N* | 144 | 117 | 144 | 117 | 144 | 117 | 144 | 117 |

*Note: Standard errors in parentheses. Dependent variable is the logarithm of the number of patents, applied or granted. Year and industry dummy variables are included. *** denotes significance at the 1%, ** at the 5% and * at the 10% level.*

Table 13: Linearized regressions, full sample. Linearized regressions of the patent production function on the complete sample.

The findings of the linearized regressions show negative PE parameters for Norway, Sweden and Scandinavia. This infers that PE is not only less potent than R&D in creating patenting activity, but actually inhibits innovation. Denmark is the only country that shows a positive effect of PE that is statistically significant. We suggest that these results are treated carefully as we suspect the findings to be affected by outliers in the dataset.

### 4.2.3 Adjusting the dataset

From the descriptive statistics it becomes clear that some industries attract large amounts of PE disbursements relative to R&D expenditures. "*Energy & environment*" receives substantial investments from PE funds, in comparison to the R&D expenditures. There is also a very low patenting activity in this industry. As "*Energy & environment*" is an outlier we investigate the effect of excluding it from the analysis and run new regressions with eight industries over a period of 13 and 16 years. Leaving "*Energy & environment*" out of the analysis also lowers the PE/R&D-ratio making it more reasonable to proceed with the linearized equation and the assumption that PE/R&D goes towards zero.[11]

[11] After excluding *"Energy & Environment"* from the dataset the PE/R&D-ratio is 30.85% in Norway, 20.68% in Sweden and 18.86% in Denmark.

| | Norway | | Sweden | | Denmark | | Scandinavia | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Applied | Granted | Applied | Granted | Applied | Granted | Applied | Granted |
| R&D Expenditure (α) | 0.322<br>(0.122)*** | 0.614<br>(0.133)*** | 0.625<br>(0.053)*** | 0.737<br>(0.063)*** | 0.604<br>(0.057)*** | 0.726<br>(0.054)*** | 0.665<br>(0.065)*** | 0.797<br>(0.070)*** |
| PE/R&D (αb) | 0.258<br>(0.165) | 0.571<br>(0.283)** | 0.160<br>(0.080)** | 0.594<br>(0.171)*** | 0.069<br>(0.042) | 0.044<br>(0.036) | 0.353<br>(0.129)*** | 0.553<br>(0.188)*** |
| *PE Parameter (b)* | 0.801 | 0.930 | 0.256 | 0.806 | 0.114 | 0.061 | 0.531 | 0.694 |
| $R^2$ | 0.95 | 0.94 | 0.99 | 0.99 | 0.97 | 0.98 | 0.99 | 0.99 |
| *N* | 128 | 104 | 128 | 104 | 128 | 104 | 128 | 104 |

*Note: Standard errors in parentheses. Dependent variable is the logarithm of the number of patents, applied or granted. Year and industry dummy variables are included. *** denotes significance at the 1%, ** at the 5% and * at the 10% level.*

Table 14: Linearized regressions, adjusted sample. Linearized regressions analysis on the patent production function with adjusted sample.

Table 14 presents the results of the linearized regressions on the dataset excluding "*Energy & environment*". Although the number of observations is lower, the fit for the regression lines and the number of significant coefficients increase compared to the analysis on the entire dataset. Furthermore, the PE parameters are much more in line with previous empirical studies, suggesting that PE disbursements do in fact contribute to innovation.[12] The PE parameters are significantly different from zero for granted patents in all cases, except Denmark. It is also worth noting that PE disbursements show a larger potency for granted patents than patent applications for all significant values. We will apply the same formula as Kortum and Lerner (2000) to interpret the results in the next chapter.

12 Kortum and Lerner (2000) and Popov and Roosenboom (2009) obtain positive values for the PE parameter in their linearized regressions.

# 5. Results

In this chapter we interpret our results and compare them to the findings of Kortum and Lerner (2000) and Popov and Roosenboom (2009). We also highlight certain limitations in our work and run robustness tests to address the credibility of our findings.

## 5.1 Interpreting the findings

Kortum and Lerner (2000) utilize the formula *b(PE/R&D)/(1+b(PE/R&D))* when assessing the impact PE disbursements have on innovation. It gives an indication of how innovation relates to PE and can be compared to the PE/R&D-ratio.

In contrast to Kortum and Lerner (2000) and Popov and Roosenboom (2009) PE disbursements seem to be less potent than R&D expenditures in our analysis. Hence, a Euro invested in R&D is more effective in promoting innovation than a Euro of PE disbursements. The potency of PE on patents in each country are shown in table 15.

| | Patent Applications (1997-2012) | | | Patents Granted (1997-2009) | | |
|---|---|---|---|---|---|---|
| | b | PE/R&D | PE potency | b | PE/R&D | PE potency |
| Norway | 0.801 | 30.85 % | 19.81 % | 0.93 | 24.58 % | 18.61 % |
| Sweden | 0.256 | 20.68 % | 5.03 % | 0.806 | 19.19 % | 13.40 % |
| Denmark | 0.114 | 18.86 % | 2.10 % | 0.061 | 21.46 % | 1.29 % |
| Scandinavia | 0.531 | 21.39 % | 10.20 % | 0.694 | 20.10 % | 12.24 % |

Table 15: Results, full sample. PE/R&D-ratio and potency of PE for patent applications and patents granted in Norway, Sweden, Denmark and Scandinavia.

We find that PE disbursements account for 10.20% of patent applications and 12.24% of granted patents in Scandinavia. The impact on granted patents is larger than the 8% Kortum and Lerner (2000) find in the US from 1983-1992. It is also larger than the 12% Popov and Roosenboom (2009) find in Europe from 1991-2004. However, the PE/R&D-ratio averages 20.10% from 1997-2009, which is considerably larger than the other studies. The fact that the impact is lower than the PE/R&D-ratio suggest that PE disbursements are less potent than R&D expenditures as means of creating innovation.

PE disbursements seem to have the strongest impact on innovation for Norwegian portfolio companies. We find that PE disbursements have accounted for 19.81% of patent applications and 18.61% of patents granted, while the ratio of PE/R&D averages 30.85% and 24.58% respectively.

In Swedish portfolio companies we find that PE disbursements have a larger impact on patents granted than patent applications. Interestingly this difference seems to be quite substantial with PE accounting for 5.03% of patent applications and 13.40% of granted patents. This implies that PE disbursements have a stronger effect on the number of ultimately successful patent applications than on the willingness to apply. Again, both findings are lower than the PE/R&D-ratios of 20.68% and 19.19%.

Our results in Denmark show that PE disbursements only account for 2.10% of patent applications and 1.29% of patents granted. Simultaneously R&D expenditures average 18.86% and 21.46% for the respective samples. This suggests that PE is particularly impotent when it comes to creating innovation in Denmark.

## 5.2 Limitations

It is important to acknowledge certain shortcomings in our research. Firstly, estimating historical Market Statistics prior to 2007 proved very challenging, both in regards to the overall PE disbursements and the distribution to industries. The assumption that investments from foreign PE funds represent a constant share of domestic investments is a simplification. We also assume that the share of PE disbursements going into each industry represents a constant share of Market Statistics. However, the attractiveness of an industry is likely to vary over time. Consequently, the deviations that we experienced when applying the calculations from 2007-2014 were quite substantial. In a couple of years, when Market Statistics are reported for a longer period and the analysis can be conducted without extrapolating values, the results might turn out to be quite different.

Secondly, there is uncertainty associated with the allocation of R&D expenditures and patents to the Invest Europe industries. The allocation is based on the assumption that all NACE 2.0 classes are distributed evenly to the industries (Appendix IV). Moreover, some R&D expenditures were missing and had to be estimated from the years before and after.

Finally, we follow the work of Kortum and Lerner (2000) although our parameters do not always support their methodology. Particularly, constraining the substitution parameters when only granted patents in Scandinavia showed results to justify this. We also argue that the PE/R&D-ratio is sufficiently small to linearize the regressions, even if it is substantially higher than the ratio presented by Kortum and Lerner (2000) and Popov and Roosenboom (2009).

It is important to keep these limitations in mind when assessing the final results, and we suggest that our findings are treated with caution.

## 5.3 Robustness

We conduct several analyses to investigate the robustness of our results. First, we run the linearized regressions on a sample of patent applications and accurate Market Statistics from 2007-2012. This way we eliminate the uncertainty associated with our estimations prior to 2007. Eight industries over six years leaves us with 48 observations for each country. The results are presented in table 16.

| | Norway | Sweden | Denmark | Scandinavia |
|---|---|---|---|---|
| R&D Expenditure (α) | 0.400<br>(0.203)* | 0.677<br>(0.077)*** | 0.527<br>(0.097)*** | 0.668<br>(0.100)*** |
| PE/R&D (αb) | 0.105<br>(0.191) | 0.051<br>(0.079) | 0.044<br>(0.048) | 0.187<br>(0.141) |
| *PE Parameter (b)* | 0.263 | 0.075 | 0.083 | 0.280 |
| $R^2$ | 0.95 | 0.99 | 0.97 | 0.99 |
| *N* | 48 | 48 | 48 | 48 |
| *Note: Standard errors in parentheses. Dependent variable is the logarithm of the number of patents, applied or granted. Year and industry dummy variables are included. *** denotes significance at the 1%, ** at the 5% and * at the 10% level.* | | | | |

Table 16: Linearized regressions, 2007-2012. Linearized regressions analysis on the patent production function on limited sample.

Although the PE parameters are lower than they were for the full sample, they are all positive, which suggest that PE disbursements have a certain effect on innovation. However, it is worth noting that none of the PE parameters are significantly different from zero. Table 17 presents the potency of PE in each country as well as the PE/R&D-ratio from 2007-2012.

| | Patent Applications (2007-2012) | | |
|---|---|---|---|
| | b | PE/R&D | PE potency |
| Norway | 0.263 | 44.77 % | 10.53 % |
| Sweden | 0.075 | 26.00 % | 1.91 % |
| Denmark | 0.083 | 20.08 % | 1.64 % |
| Scandinavia | 0.28 | 26.73 % | 6.96 % |

Table 17: Results, 2007-2012. PE/R&D-ratio and potency of PE for patent applications in Norway, Sweden, Denmark and Scandinavia.

The findings from the sample with accurate Market Statistics are somewhat coinciding with previous results. The PE potencies are still positive, but generally lower than the case was for the entire sample. Simultaneously, the PE/R&D-ratio is higher than before. These findings suggest PE is even more inferior to R&D as means of creating innovation in recent years. We want to emphasize that the analysis is based on very few observations and the findings do not show any statistical significance.

To further assess the robustness, we conduct a differences analysis. If the errors in the function follow a random walk, the equation should be estimated in differences rather than in levels. We divide the dataset in period averages of the logarithm of each variable. For patent applications we obtain four 4-year periods and for granted patents we use one 4-year period and three 3-year periods. We compute the differences between periods that are 3-4 years apart and apply linearized regressions. The results of the regressions are shown in table 18.

| | Norway | | Sweden | | Denmark | | Scandinavia | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Applied | Granted | Applied | Granted | Applied | Granted | Applied | Granted |
| R&D Expenditure (α) | 0.195<br>(0.196) | -0.457<br>(0.403) | 0.056<br>(0.303) | -0.505<br>(0.484) | 0.262<br>(0.257) | 0.025<br>(0.189) | 0.425<br>(0.318) | -0.959<br>(0.444)* |
| PE/R&D (αb) | -0.301<br>(0.251) | 0.507<br>(0.440) | -0.098<br>(0.151) | -0.408<br>(0.306) | 0.059<br>(0.061) | 0.076<br>(0.055) | 0.075<br>(0.178) | -0.272<br>(0.194) |
| *PE Parameter (b)* | -1.544 | -1.109 | -1.75 | 0.808 | 0.225 | 3.04 | 0.176 | 0.284 |
| $R^2$ | 0.68 | 0.15 | 0.42 | 0.35 | 0.46 | 0.14 | 0.58 | 0.50 |
| *N* | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |

*Note: Standard errors in parentheses. Dependent variable is the logarithm of the number of patents, applied or granted. Year and industry dummy variables are included. *** denotes significance at the 1%, ** at the 5% and * at the 10% level.*

Table 18: Differences analysis. First difference analysis of the complete sample. Periods for granted patents are: 1997-2000, 2001-2003, 2004-2006, 2007-2009. Periods for patent applications are: 1997-2000, 2001-2004, 2005-2008, 2009-2012.

The PE parameters, are different from our previous results. Negative values imply that PE prevents innovation, which is contradictory to what we found in our main analysis. It is worth noting that a small number of initial observations leave us with just 16 observations when conducting the differences analysis. This might not be enough to present us with reliable results. Nevertheless, the results infer that our findings are not particularly robust.

Finally, we want to investigate the effect of changing the measures of PE. We replace the PE disbursements with VC disbursements and obtain a lower PE/R&D-ratio that is more in line with Kortum and Lerner (2000). As we do not have applicable VC disbursements prior to 2007 we conduct the linearized regressions on a sample of patent applications from 2007-2012.

| | Norway | Sweden | Denmark | Scandinavia |
|---|---|---|---|---|
| Parameter | Applied | Applied | Applied | Applied |
| R&D Expenditure (α) | 0.325<br>(0.213) | 0.666<br>(0.071)*** | 0.606<br>(0.088)*** | 0.669<br>(0.093)*** |
| PE/R&D (αb) | 3.129<br>(2.633) | -2.292<br>(2.441) | -13.169<br>(3.949)*** | -6.473<br>(3.460)* |
| *PE Parameter (b)* | 9.828 | -3.441 | -21.731 | -9.676 |
| $R^2$ | 0.95 | 0.99 | 0.98 | 0.99 |
| *N* | 48 | 48 | 48 | 48 |

*Note: Standard errors in parentheses. Dependent variable is the logarithm of the number of patents, applied or granted. Year and industry dummy variables are included. *** denotes significance at the 1%, ** at the 5% and * at the 10% level.*

Table 19: Linearized regressions, venture capital. Linearized regressions performed on VC disbursements, instead of PE disbursements from 2007-2012.

Table 19 shows that the PE parameters vary a lot from positive in Norway to strongly negative in Denmark, which is not coinciding with the findings in table 15. This inconsistency supports the findings from our differences analysis and suggests that our findings are not particularly robust.

Kortum and Lerner (2000) continue their analysis by addressing causalities to investigate whether the results are affected by any unobservable factors. In our case, the results are not robust enough for us to gain additional insight by addressing the causalities. Hence, we will treat our findings from the linearized regressions on the full sample as our final results. We want to emphasise that they should be treated with caution due to the low robustness.

# 6. Conclusion

This thesis examines the impact of PE on innovation in Norway, Sweden and Denmark. We investigate the contribution PE disbursements have on patents granted from 1997-2009 and patent applications from 1997-2012. Based on previous empirical studies we expected to find PE to be more potent than R&D in creating innovation.

PE disbursements have the largest impact on both patents granted and patent applications in Norwegian portfolio companies. In Sweden and Denmark, PE also shows a positive effect on patenting activity. However, the PE potency is lower than the PE/R&D-ratio in all cases, suggesting that PE disbursements are less potent than R&D expenditures in creating innovation in Scandinavia. We have controlled the robustness of our results by introducing different variations of our dataset. The results do not coincide with our initial results, which infer that our findings are not particularly robust.

Our findings are contradictory with previous empirical studies on the relationship between PE and innovation. Kortum and Lerner (2000) find that VC have accounted for 8% of innovation with a VC/R&D-ratio of 3% in the US from 1983-1992, while Popov and Roosenboom (2009) find that PE have accounted for 12% of innovation with a PE/R&D-ratio of 8%. Although we find that PE disbursements contribute more to innovation in Norway and Sweden, the potency of PE is lower due to a higher PE/R&D-ratio.

Our work should be seen as a first draft of PE's impact on innovation in Scandinavian portfolio companies. It is important to note that our results are affected by estimations and adjustments to the dataset. Although the findings did not show much robustness, we hope this thesis can initiate further research on the relationship between PE and innovation in Scandinavia. Lerner, Sorensen and Strömberg (2011) find that patents filed in the US from companies that are backed by PE funds tend to be more economically relevant, as measured by the number of citations. While this thesis is limited to the effect PE disbursements have on patenting activity, it would be interesting to investigate if the quality of the patents increase with involvement of PE firms.

# References


Abramovitz, M. (1956). Resource and Output Trends in the United States Since 1870. In: M. Abramovitz, ed., *Resource and Output Trends in the United States Since 1870*, 1st ed. NBER, pp.1-23.

Amess, K., Stiebale, J. and Wright, M. (2015). The Impact of Private Equity on Firms' Innovation Activity. Düsseldorf: Düsseldorf Institute for Competition Economics (DICE).

Correspondence table NACE Rev. 1.1 - NACE Rev. 2. (2008). 1st ed. [ebook] European Commission. Available at: http://ec.europa.eu/eurostat/documents/1965800/1978760/CORRESPONDENCETABLENACEREV.1.1-NACEREV.2.pdf/e8200936-c2f0-4202-8bda-99fbbfc422b4 [Accessed 1 Mar. 2016].

Ec.europa.eu. (2016). *Europa - RAMON - Classification Detail List*. [online] Available at: http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NACE_REV2 [Accessed 7 Mar. 2016].

Ec.europa.eu. (2016). *NACE background - Statistics Explained*. [online] Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/NACE_background [Accessed 10 Mar. 2016].

Gilligan, J. and Wright, M. (2014). *Private equity demystified*. 3rd ed. London: ICAEW Corporate Finance Faculty.

Griliches, Z. (1986). Productivity, R&D, and the Basic Research at the Firm Level in the 1970´s. *American Economic Review*, 76, pp.141-154.

Hagedoorn, J. and Cloodt, M. (2003). Measuring innovative performance: is there an advantage in using multiple indicators?. *Research Policy*, 32(8), pp.1365-1379.

Kortum, S. and Lerner, J. (2000). Assessing the Contribution of Venture Capital to Innovation. *The RAND Journal of Economics*, 31(4), pp.674-692.

Lerner, J., Sorensen, M. and Strömberg, P. (2011). Private Equity and Long-Run Investment: The Case of Innovation. *The Journal of Finance*, 66(2), pp.445-477.

Popov, A. and Roosenboom, P. (2009). Does private equity investment spur innovation? Evidence from Europe. *European Central Bank, Working paper series*, 1063(June), pp.1-43.

Rosenberg, N. (2004). *Innovation and economic growth*. 1st ed. [ebook] OECD. Available at: https://www.oecd.org/cfe/tourism/34267902.pdf [Accessed 9 May 2016].

Sectorial Classification. (2007). 1st ed. [ebook] EVCA. Available at: http://www.investeurope.eu/media/12926/sectoral_classification.pdf [Accessed 8 Feb. 2016].

**PE disbursements**

Invest Europe Yearbooks 1989-2006. (n.d.). [xlsx] Invest Europe.

Invest Europe Yearbooks 2007-2015. (2015). [xlsx] Invest Europe.

**R&D Expenditures:**

Forskning og utvikling i næringslivet. (n.d.). [xlsx] Statistics Norway, Egenutført FoU i næringslivet, etter detaljert næring.

Forskning og utvikling i næringslivet. (n.d.). [xlsx] Statistics Norway, Kostnader til egenutført FoU-aktivitet i næringslivet, etter detaljert næring.

FoU inom företag. (2008). [Table] Statistics Sweden, FoU-utgifter fördelade på kostnadsslag, investeringar och konsultarvoden efter näringsgren SNI02. Vartannat år 1995 - 2007.

Företagens utgifter för egen utförd FoU efter näringsgren 2007–2013. (n.d.). [Table] Statistics Sweden.

Forskning og udviklingsarbejde i erhvervslivet 2006. (2006). [pdf.] Statistics Denmark, Tabelsamling erhvervslivet.

Forskning og udvikling i erhvervslivet. (2014). [xlsx] Statistics Denmark, Tabelsamling.

Business enterprise R&D expenditure (BERD) by economic activity (NACE Rev. 2). (n.d.). [Table] Eurostat, rd_e_berdindr2.

**Patents**

Patent applications to the EPO by priority year by NACE Rev. 2 activity. (n.d.). [Table] Eurostat, pat_ep_nnac2.

Patents granted by the USPTO by priority year by NACE Rev. 2 activity. (n.d.). [Table] Eurostat, pat_us_nnac2.

# Appendix

## I. Market Statistics vs. Industry Statistics

| Norway | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|
| Market Statistics | 1 178 504 | 1 124 709 | 709 223 | 1 886 733 | 905 065 | 966 689 | 1 680 988 | 2 208 987 |
| Industry Statistics | 698 490 | 770 121 | 641 737 | 936 284 | 706 154 | 879 930 | 882 790 | 1 285 460 |
| **Difference** | **480 013** | **354 588** | **67 486** | **950 450** | **198 911** | **86 759** | **798 197** | **923 527** |
| **Sweden** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| Market Statistics | 3 085 305 | 2 288 301 | 1 112 092 | 2 766 545 | 3 354 258 | 2 527 281 | 813 875 | 1 421 464 |
| Industry Statistics | 3 010 276 | 3 330 254 | 1 337 055 | 3 134 891 | 2 166 423 | 2 021 800 | 1 556 944 | 1 598 501 |
| **Difference** | **75 029** | **-1 041 952** | **-224 963** | **-368 346** | **1 187 835** | **505 481** | **-743 069** | **-177 037** |
| **Denmark** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| Market Statistics | 1 835 153 | 1 207 400 | 479 041 | 385 657 | 880 586 | 861 573 | 1 868 187 | 1 250 285 |
| Industry Statistics | 1 334 179 | 512 093 | 452 496 | 439 230 | 421 284 | 693 552 | 1 484 319 | 662 299 |
| **Difference** | **500 974** | **695 307** | **26 545** | **-53 572** | **459 303** | **168 021** | **383 868** | **587 987** |

A comparison between Market and Industry Statistics reported by Invest Europe shows substantial differences in all countries.

# II. Estimated Market Statistics 1997-2006

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Norway - Domestic investments** | 131 761 | 132 808 | 156 816 | 257 310 | 235 920 | 147 394 | 185 309 | 220 076 | 384 879 | 426 731 |
| **Multiple** | **1.7801** | | | | | | | | | |
| **Norway - estimated Market Statistics** | 234 548 | 236 412 | 279 149 | 458 039 | 419 962 | 262 377 | 329 869 | 391 758 | 685 125 | 759 626 |
| **Sweden - Domestic Investments** | 278 300 | 199 365 | 832 189 | 1 367 552 | 1 623 189 | 612 129 | 818 642 | 1 339 757 | 1 691 595 | 2 808 951 |
| **Multiple** | **1.4038** | | | | | | | | | |
| **Sweden - estimated Market Statistics** | 390 686 | 279 875 | 1 168 252 | 1 919 810 | 2 278 681 | 859 325 | 1 149 234 | 1 880 791 | 2 374 712 | 3 943 289 |
| **Denmark - Domestic Investments** | 17 344 | 30 185 | 112 756 | 112 756 | 280 674 | 161 383 | 381 639 | 320 935 | 982 833 | 319 851 |
| **Multiple** | **2.0885** | | | | | | | | | |
| **Denmark - estimated Market Statistics** | 36 223 | 63 041 | 235 489 | 235 489 | 586 184 | 337 046 | 797 048 | 670 268 | 2 052 633 | 668 004 |

Estimation of Market Statistics from 1997-2006. Showing the multiple used in each country in order to extrapolate the used Market Statistics prior to 2007.

# III. Conversion tables - NACE 1.1 to NACE 2.0

| Norway | | |
|---|---|---|
| NACE 1.1 | Allocation | NACE 2.0 |
| 5 | 100 % | A03 |
| 11 | 100 % | B05-B09 |
| 13-14 | 100 % | B05-B09 |
| 15-16 | 100 % | C10-C11 |
| 17 | 100 % | C13 |
| 18 | 100 % | C14-C15 |
| 19 | 100 % | C14-C15 |
| 20 | 100 % | C16 |
| 21 | 100 % | C17 |
| 22 | 40 % | C18 |
| | 60 % | J58 |
| 23 | 100 % | C19-C20 |
| 24 | 65 % | C19-C20 |
| | 35 % | C21 |
| 25 | 100 % | C22 |
| 26 | 100 % | C23 |
| 27 | 100 % | C24 |
| 28 | 90 % | C25 |
| | 10 % | C33 |
| 29 | 20 % | C25 |
| | 20 % | C27 |
| | 40 % | C28 |
| | 10 % | C32.5 |
| | 10 % | C33 |
| 30 | 50 % | C26 |
| | 50 % | C28 |
| 31 | 50 % | C26.3 |
| | 20 % | C26.5 |
| | 20 % | C27 |
| | 10 % | C33 |
| 32 | 40 % | C26 |
| | 60 % | C26.3 |
| 33 | 50 % | C26.5 |
| | 50 % | C28 |
| 34-35 | 40 % | C29 |
| | 60 % | C30 |
| 36-37 | 70 % | C31 |
| | 30 % | C32 |
| 40-41 | 90 % | D35 |
| | 10 % | E36-E39 |
| 45 | 100 % | F41-F43 |
| 51 | 100 % | G46 |
| 60-63 | 100 % | H49-H53 |
| 64.2 | 100 % | J61 |
| 65-67 | 100 % | K64-K66 |
| 72 | 37.50 % | J58 |
| | 60 % | J62 |
| | 2.50 % | J63 |
| 73 | 100 % | M71 |
| 74 | 90 % | M71 |
| | 10 % | M74.9 |

| Sweden | | |
|---|---|---|
| SNI92 | Allocation | NACE 2.0 |
| A+B | 100 % | A03 |
| 10-14 | 100 % | B05 - B09 |
| 15+16 | 100 % | C10-C12 |
| 17-19 | 100 % | C13-C15 |
| 20 | 100 % | C16 |
| 21 | 100 % | C17 |
| 22 | 40 % | C18 |
| | 60 % | J58 |
| 23+24 ex 24.42 | 100 % | C20 |
| 24.42 | 100 % | C21 |
| 25 | 100 % | C22 |
| 26 | 100 % | C23 |
| 27 | 100 % | C24 |
| 28 | 90 % | C25 |
| | 10 % | C33 |
| 29 | 20 % | C25 |
| | 20 % | C27 |
| | 40 % | C28 |
| | 10 % | C32.5 |
| | 10 % | C33 |
| 30 | 50 % | C26 |
| | 50 % | C28 |
| 31 | 50 % | C26.3 |
| | 20 % | C26.5 |
| | 20 % | C27 |
| | 10 % | C33 |
| 32 | 40 % | C26 |
| | 60 % | C26.3 |
| 33 | 50 % | C26.5 |
| | 50 % | C28 |
| 34-35 | 40 % | C29 |
| | 60 % | C30 |
| 36-37 | 70 % | C31 |
| | 30 % | C32 |
| E | 90 % | D35 |
| | 10 % | E36-E39 |
| F | 100 % | F41-F43 |
| G | 100 % | G46 |
| 60-63 | 100 % | H49-H53 |
| 64 | 100 % | J61 |
| J | 100 % | K64-K66 |
| 72 | 37.50 % | J58 |
| | 60 % | J62 |
| | 2.50 % | J63 |
| 73 | 100 % | M72 |
| 74 | 90 % | M71 |
| | 10 % | M74 |

| Denmark | | |
|---|---|---|
| NACE 1.1 | Allocation | NACE 2.0 |
| 15-16 | 100 % | C10-C12 |
| 17-19 | 100 % | C13-C15 |
| 20 | 100 % | C16 |
| 21 | 100 % | C17 |
| 22 | 40 % | C18 |
| | 60 % | J58 |
| 23+24 ex 24.4 | 100 % | C20 |
| 24.4 | 100 % | C21 |
| 25 | 100 % | C22 |
| 26 | 100 % | C23 |
| 27 | 100 % | C24 |
| 28 | 90 % | C25 |
| | 10 % | C33 |
| 29 | 20 % | C25 |
| | 20 % | C27 |
| | 40 % | C28 |
| | 10 % | C32.5 |
| | 10 % | C33 |
| 30 | 50 % | C26 |
| | 50 % | C28 |
| 31 | 50 % | C26.3 |
| | 20 % | C26.5 |
| | 20 % | C27 |
| | 10 % | C33 |
| 32 | 40 % | C26 |
| | 60 % | C26.3 |
| 33 | 50 % | C26.5 |
| | 50 % | C28 |
| 34-35 | 40 % | C29 |
| | 60 % | C30 |
| 36-37 | 70 % | C31 |
| | 30 % | C32 |
| E | 90 % | D35 |
| | 10 % | E36-E39 |
| F | 100 % | F41-F43 |
| G | 100 % | G46 |
| 60-63 | 100 % | H49-H53 |
| 64 | 100 % | J61 |
| J | 100 % | K64-K66 |
| 72 | 37.50 % | J58 |
| | 60 % | J62 |
| | 2.50 % | J63 |
| 73 | 100 % | M72 |
| 74 | 90 % | M71 |
| | 10 % | M74 |

Conversion tables used in order to convert R&D expenditures prior to 2007 into NACE 2.0 in Norway, Sweden and Denmark.

# IV. Distribution system - NACE 2.0 to Invest Europe industries

| | Observations | | Invest Europe industries | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NACE Code | # of ind | # Total | Agriculture | | Business & Industrial Products | | Business & Industrial Services | | Chemicals and Materials | | Communications | | Computer & Consumer Electronics | | Construction | | Consumer Goods & Retail | | Consumer Services | | Energy and Environment | | Financial Services | | Life Sciences | | Transportation | |
| | | | Obs | w | Obs | w | Obs | w | Obs | w | Obs | w | Obs | w | Obs | w | Obs | w | Obs | w | Obs | w | Obs | w | Obs | w | Obs | w |
| C22 | 4 | 5 | | | 2 | 0,4 | | | 1 | 0,2 | | | | | 1 | 0,2 | 1 | 0,2 | | | | | | | | | | |
| C23 | 4 | 24 | | | 2 | 0,083 | | | 5 | 0,208 | | | | | 12 | 0,5 | 5 | 0,208 | | | | | | | | | | |
| C24 | 1 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| C25 | 2 | 17 | | | 15 | 0,882 | | | | | | | | | 2 | 0,118 | | | | | | | | | | | | |
| C27 | 2 | 10 | | | 8 | 0,8 | | | | | | | | | | | 2 | 0,2 | | | | | | | | | | |
| C31 | 2 | 4 | | | 1 | 0,25 | | | | | | | | | | | 3 | 0,75 | | | | | | | | | | |
| C32 / C32.5 | 2 | 8 | | | 1 | 0,125 | | | | | | | | | | | 7 | 0,875 | | | | | | | | | | |
| C32.5 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| G46 / G46.5 | 7 | 46 | 4 | 0,087 | | | 8 | 0,174 | 2 | 0,043 | | | | | 2 | 0,043 | 18 | 0,391 | | | 3 | 0,065 | 9 | 0,196 | | | | |
| G46.5 | 2 | 2 | | | | | | | | | 1 | 0,5 | 1 | 0,5 | | | | | | | | | | | | | | |
| K64, K65, K66 | 2 | 0<br>18<br>0 | | | | | | | | | | | | | | | | | 1 | 0,056 | | | 17 | 0,944 | | | | |
| M / M72 | 1 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| M72 | 2 | 3 | | | | | | | | | | | | | | | | | 1 | 0,333 | | | | | 2 | 0,667 | | |

Distribution table used in order to distribute R&D expenditures and patent observations to Invest Europe's industries. Real estate and Unclassified are missing as there were nothing to distribute.
Each industry are divided by *Obs*, and *w*. *Obs* denotes the number of observations within the specified NACE code. *w* denotes the weight the industry is given.