Universiteit Leiden

ICT in Business

Impact of regional innovator networks on academic commercialization output

-Evidence from 2 Dutch technological science parks-

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SUMMARY

Orientation: This research started with the question of how universities are connected to their regional innovation system.

Research purpose: The purpose of this study is to provide insights in how a regional economy, and the innovator network in particular, impact the innovativeness and commercial success of a University.

Motivation for the study: I believe that there is an interesting contrast between the philosophies of Universities and industry. Professors do research for the sake of science, and industry often researches for the sake of financial profit. We have entered the era where these two worlds have come together. I was personally interested into seeing how academics and industry professionals can collaborate and share knowledge. Many articles write about the "knowledge spillover", which means that Universities "push" too much knowledge to be absorbed by their regional environment. One article in particular, reversed this theory, and researched how a University needs it's regional innovation system to "pull" knowledge for commercial purposes. This paper uses a patent analysis on two US regions and inspired me to research how European, or Dutch universities collaborate with their innovative environment.

Research design, approach and method: Two Dutch regions were compared. Both regions host a University with technology focused faculties, which are surrounded by a science park. The Delft region hosts the Delft University of Technology (TU Delft), and the Twente region hosts the University of Twente (UTwente). We compared data from the years 2000-2010. Firstly, the universities commercial success was compared through measuring the amount of patent applications, the third income stream and the amount of spin-offs. Secondly, the innovator networks were created from data from the EPO PATSTAT Spring 2015 database. A total of 2306 patents were drawn from the database, involving a total of 2403 unique inventors. We compared the network size and the network main component (NMC). Afterwards a social network analysis determined which of the inventors in the network are academics, and which are industry professionals. This analysis was used to gain insight in how these two parties collaborate in the regions.

Main findings and implications: The TU Delft is relatively speaking twice the size of UTwente in terms of overall income, employees and student amounts. We would expect the TU Delft to have twice the commercial performance. Even though it's third income stream and amount of spinoffs meet this expectation, the TU Delft applies for 4 times more patents than UTwente. With this increased commercial performance, we saw that the Delft network and the network main component are much bigger in size. Both universities commercial performance also grew over the years, together with the network size and the NMC size in both regions. From this we conclude that the size of the inventor network, as well as the size of the NMC, positively influence the universities commercial success. We hypothesized that more collaboration between academic inventors and industry inventors leads to increased commercial performance of the regions university. We found enough evidence to support this hypothesis, but the Twente region seemed more saturated with academics. 40% of inventors are academics, in comparison to Delft's 20%. From this observation we could argue that both universities put se same amount of effort into collaborating with their regional innovation system. But even though the Twente region has relatively more links between academics and industry professionals, the difference of the networks sheer size provides TU Delft with more commercial collaboration opportunities.

Contribution: This thesis contributes to regional innovation system literature by providing new insights in the Universities role as an actor. Even though US Universities have more incentives to commercialize knowledge, Dutch universities are getting more and more involved in their regional innovation system, as their commercial success is increasing vastly. However, Dutch universities still have a hard time commercializing their inventions. Due to many patent applications by TU Delft, pairing with an only slightly increased third income stream. This finding is in line with the "European Paradox", a much researched phenomenon in European innovation literature.

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KEYWORDS

Regional innovation systems, Inventor network, Academic commercialization, patents.

ABSTRACT

This thesis aims to measure the impact of regional innovator networks on academic commercialization output. Data from 2306 patents between 2000 and 2010 is used to create two innovator networks, which are then compared to the universities of the Twente and Delft regions. This study found that the size of the network, and the size of the network main component positively impact the region's universities commercial success. Even though both regions networks show excellent collaboration between industry professionals and academics, the difference of the networks sheer size provides TU Delft with more commercial collaboration opportunities.

CONTENTS

1 INTRODUCTION

We now live in a vastly changing world, new technologies emerge and are adopted at high speed. Firms have to be more dynamic and innovative to react to the changes in their respective industries, and policy makers struggle with the constant threat of digital security and privacy issues. We have now come to a point where creating and sharing knowledge is essential for every institution of society, public or private. It is nothing new that Universities play an increased role in creating and sharing knowledge. But the fact is, that income streams of Universities have also been changing over the past few decades. Less public funding led to more commercialized methods of income.

The topic of academic commercialization interests me. Modern universities are finding more creative ways to generate income, this means that the university is becoming more and more innovative. It can adapt to the changing environment and needs just like any other organization. Not only generating knowledge, but also the diffusion and creation of value are what define an innovation. Dutch universities are often positioned in the center of a science park, which allows for transition of theoretical knowledge to practical use in industry (Edwin Mansfield & Lee, 1996; Edwin Mansfield, 1995).

> *"If you look at history, innovation doesn't come just from giving people incentives; It comes from creating environments where their ideas can connect"*
>
> *– Steven Johnson*

Universities have been evolving for a long time due to fast societal changes. The traditional university used to only function as a storehouse of knowledge, accessible by only the elite of society. Then, at the beginning of the industrial age, the university started to play a more active role, and started to focus more on using rational inquiry and experimentation. universities started educating students to transfer useful knowledge based on the needs of the industry. universities changed from knowledge "storehouses" to knowledge "factories (Youtie & Shapira, 2008).

Some researchers talk about the modern university as being more like an 'innovation hub' ; the center of its regional innovation system (Youtie & Shapira, 2008). Hybrid organizations like TTO's (Technology Transfer Offices) are emerging to connect public research institutions to industry by valorizing academic knowledge (Ho, Liu, Lu, & Huang, 2014). Many factors have led to the current universities changing business model. Governmental structural funds are declining and Universities have to compensate by increasing funds from non-profit organizations and more collaboration with the industry (Geuna & Nesta, 2006). Universities collaborate with the industry in many different ways, be it informal-, formal contact, collaborative research, sharing resources (labs/equipment) or the recruitment of employees (Fritsch & Schwirten, 1999). But universities also have started to engage in commercialization activities. Be it through university spin-offs, TTO's or assisting students with valorizing their innovative ideas (Miller, McAdam, & McAdam, 2014). Most of which include academic institutions to acquire Intellectual Property Rights (IPR) over their knowledge. Innovation policy researchers say, that next to education and research, universities have received a third "mission" (Geuna & Rossi, 2011; Paleari, Donina, & Meoli, 2014; Perkmann et al., 2013). Not only in the United States, where universities are often private institutes, but also in the Netherlands we see that Universities partake in commercial activities more and more. Professor Wissema from TU Delft goes as far in describing the modern university as "The Third Generation University"(Duke, 2009; Wissema, 2005).

This new mission or role of universities is to animate regional economic and social development (Etzkowitz, 2002; Gunasekara, 2006). The way knowledge is valorized is therefore highly influenced, not only on the universities "push" strategy, but also on how the industry "pulls" knowledge from institutes (Casper, 2013).

This study suggested that university commercialization output is heightened by strong social networks between inventors in the regional innovation system.

This thesis will add to this theory by using patenting data from 2 very diverse Dutch technological science parks. A contribution will be made to the innovation policy literature, as Casper's study was conducted on San Francisco and Los Angeles, and was focused on bio-science parks. A European counterpart to the study could provide us with interesting new insights on academic commercialization in Europe. This research will also provide new insights in academic-industry cooperation. The inventor network analysis includes a detailed online resume check to pin down academics in the inventor network.

This thesis will primarily aim to answer the following question:

"Is the commercial performance of a University positively influenced by the strength of the social ties in its regional innovator network?"

Patenting data will be used to generate an elaborate inventor network, this social network analysis is used to examine the quality of social ties between academics and industry. Stronger social ties with industry could lead to a more accessible way for academics to commercialize and valorize their knowledge. The hypothesis of stronger social ties linking to an increased academic commercialization output will be tested with this method.

As a first step, we need to clarify about what is meant with the strength of social ties in an innovator network, and how we can measure it. Three measures are used to determine how strong the social ties in the innovator network are. These are (1) the size of the network , (2) the size of the network main component , and (3) the amount of academics there are in the network. This allows us to arrive to three hypotheses that prove beneficial in correctly answering the research question.

Hypothesis 1: "The size of the regional inventor network positively influences the universities commercial success"

Hypothesis 2: "The size of the regional network main component positively influences the universities commercial success"

Hypothesis 3: "more collaboration between academic inventors and industry inventors leads to increased commercial performance of the university in a region"

In the literature review, I start with defining and investigating regional innovation systems, university industry links and academic commercialization. In the third chapter, I propose the research methodology. Afterwards the results will be presented and discussed. Chapter five provides the conclusion with answering the research question, provide questions for further research and the limitations will be discussed.

2 LITERATURE REVIEW

The literature review will provide the necessary information and definitions so the foundations of this research thesis can be understood. Firstly, Regional Innovation Systems are elaborated on. The focus is mainly on what they are and how their performance is measured in existing literature. Then the literature will be reviewed on the universities current role in Regional Innovation Systems. In the light of universities "third" commercial role, we will then put the focus on European universities, how they commercialize and the link with regional inventor networks.

2.1 REGIONAL INNOVATION SYSTEMS

To understand regional innovation systems and the purpose of this research field, we will first look into the definition of Innovation. Like any other concept, innovation can have different definitions. Common dictionaries broadly describe innovation as "*introducing something new*"[1] or *"something newly introduced, such as a method or device"*[2]. From a scientific standpoint, introducing something new is only the last phase of the interactive process we call innovation. Therefore, following Fischer's theory (Fischer, 2001), innovation will be defined as the creation, diffusion and use of knowledge.

A system can be generally described as a group of components working towards reaching a common objective. An innovation system's components are the actors, networks and institutions working together to create, diffuse and utilize knowledge. Often identified in the form of creating new products and processes (Bergek et al., 2008). However, the components could interact unplanned and unintentional, even though the theory would suggest a more collective and coordinated interaction. Even though some actors are working towards a common goal, most are probably not consciously doing so. (Carlsson and Stankiewicz, 1991) believed that these systems are defined in terms of knowledge and competence flows rather than flows of goods or services. They also brought forth the theory that these networks can be transformed into development blocks, which are synergistic clusters of technologies and firms which can create business opportunities.

Literature identifies different types or concepts of Innovation Systems. These mostly differ in how the boundaries of the system are declared. For instance; a Technological Innovation System (TIS) focuses on a particular technology and includes all actors for this technology within its boundaries (Bergek et al., 2008). A National System of Innovation (NSI) uses a countries borders as a boundary for the Innovation System (Motohashi, 2005).

This is very similar to Carlsson and Stankiewicz's perspective on systemic innovation, who noted that:

...nation-state constitutes a natural boundary of many technological systems. Sometimes, how- ever, it may make sense to talk about a regional or local technological system .... In yet other cases the technological systems are international, even global. (Carlsson & Stankiewicz, page 111, 1991)

This thesis will focus on Regional Innovation Systems (RIS) rather than a 'sectorial' or 'technological' approach. A RIS identifies actors, networks and institutions that interact with the regional governance and innovation support infrastructures. Figure 1 one can be seen as a visual example of this concept. Different actors and

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[1] American Heritage® Dictionary of the English Language, Fifth Edition. Copyright © 2011 by Houghton Mifflin Harcourt Publishing Company. Published by Houghton Mifflin Harcourt Publishing Company.

[2] Random House Kernerman Webster's College Dictionary, © 2010 K Dictionaries Ltd. Copyright 2005, 1997, 1991 by Random House, Inc.

institutions (Enterprises, RI's, Transfer offices, Banks) are connected in many ways, which creates a network. Besides market- and non-market oriented interactions there are also other ways actors can interact. Tensions, competition and more informal contacts can also be part of an Innovation System.

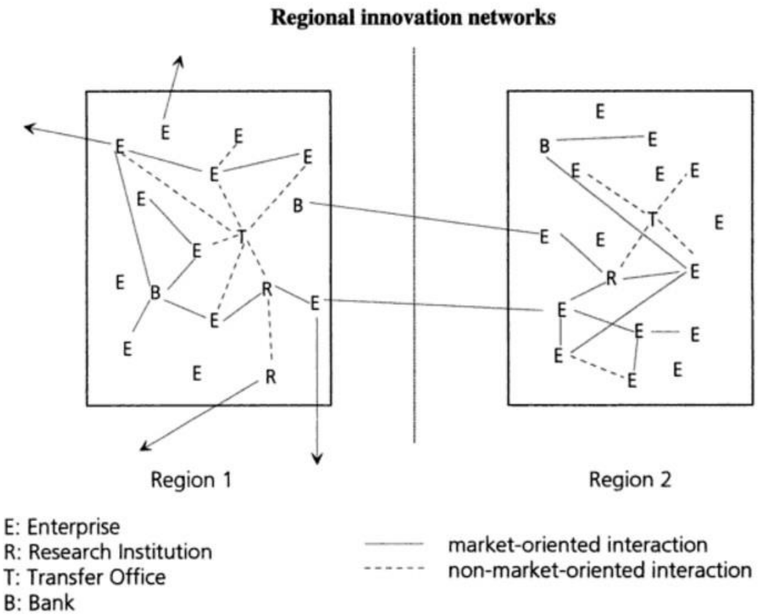


Figure 1, Regional Innovation Networks (Koschatzky, Kulicke, & Zenker, 2001)

Many studies are based around measuring the performance of an innovation system. For Regional innovation systems, empirical evidence suggests that patents provide a fairly reliable measure of its innovative activity (Acosta, Coronado, León, & Martínez, 2009; Acs, Anselin, & Varga, 2002). But these studies also suggested that it would be more accurate, to instead use patent counts as a measure for the amount of new knowledge created in a region. One study claimed that patents do not correctly measure the economic value of technologies, even though they are a good measure of new technology creation (Hall, Jaffe, & Trajtenberg, 2001).This resulted in patent counts merely being used as indicators of the quantity, rather than the quality of innovation (Cowan & Zinovyeva, 2013).

It was made clear that more data is required to correctly measure the performance of a RIS. A study by Zabala (Zabala-Iturriagagoitia, Voigt, Gutiérrez-Gracia, & Jiménez-Sáez, 2007) applied a Data Envelopment Analysis (DEA) method to achieve this. This research resulted in an elaborate representation of the performance of European regional innovation systems. He used quantitative and qualitative methods and used several variables from the European Innovation Scoreboard (EIS) and the European Patent Organization (EPO). These variables included:

- the percentage of population in higher education
- the percentage of population participating in lifelong learning activities
- the percentage of the total workforce in medium/high-tech employment
- the percentage of the total workforce in high-tech employment
- public R&D expenditure
- business R&R expenditure
- high-tech patent applications to the EPO

The study will not attempt to measure the RIS performance, instead its focus will be more on the social networks, and connectedness between inventors in a RIS.

2.2 UNIVERSITIES ROLE IN REGIONAL INNOVATION SYSTEMS

This study looks at the relation between Universities and their surrounding industry. Both play an important role in their regional innovation system, but what connects these two actors the most? When focused on a regional innovation system, 3 main actors can be identified. Academia and Industry (both in figure 1), and also Governments are involved. Academics create and diffuse knowledge, industry use and commercialize it, and governments apply policy to this process. However, more and more hybrid organizations are starting to emerge. Technology Transfer Offices(TTO) and other Incubators are part of the Triple-helix-model (Etzkowitz, 2002). Figure 2 shows the transition from the traditional etatistic model to the Triple helix model.

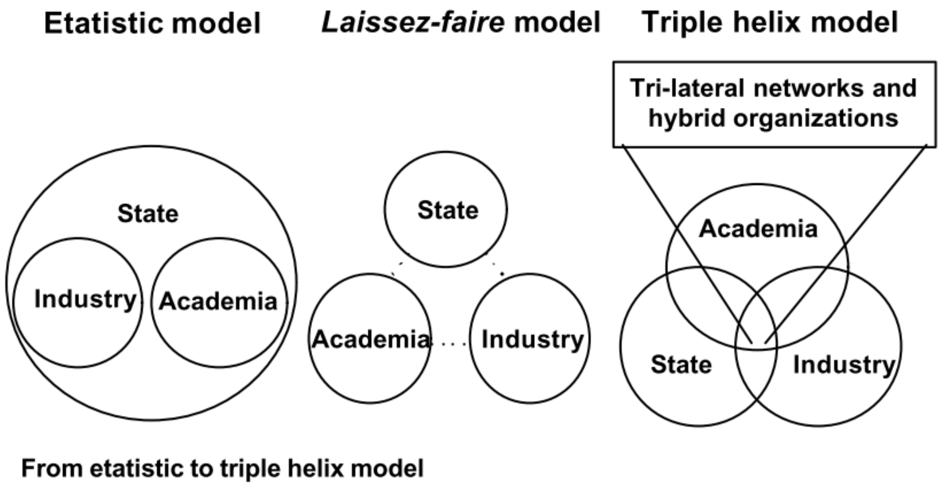


figure 2, from etatistic to triple helix model, (Etzkowitz, 2002)

The theory that emerged in the second half of the 1990's suggests that innovation is more and more important in the relationship between the 3 actors in figure 2. Academics are working with industry (entrepreneurial activities or patenting ideas for commercialization) and business strategy is not uncommon anymore in governmental institutes. Institutions are forced to adapt to hybrid roles that are different from the initial understandings of each sector. These hybrid roles are taken on by Incubators, like valorization centers and TTO's. These incubators increase the strength of the network with activities like providing legal advice to startups and connecting entrepreneurs and academics with industry (Etzkowitz, 2002). A TTO's mission for instance, is to transfer knowledge from universities to industry. TTO's have already become an unmissable link in valorization efforts of universities, and in the overall triple helix model. (Debackere & Veugelers, 2005; Miller et al., 2014; Siegel, Veugelers, & Wright, 2007). University entrepreneurship programs and incubator facilities create an interactive process for technology transfer which replaces the traditional linear flow

Around the same time of the triple helix theory, empirical evidence showed that especially Europe had difficulties in exploiting basic research into economic value (European Commission, 1995). This was called the European Paradox.

"One of Europe's major weaknesses lies in its inferiority in terms of transforming the results of technological research and skills into innovations and competitive advantages."

(European Commission, page 5 , 1995)

A better understanding of industry-science links then became more valuable to many OECD countries, thus more research was conducted in this field.

From early on it has been clear that university-industry links have been of key importance in promoting technological change in many industries (Edwin Mansfield & Lee, 1996). Even in 1975-1985, academic research led to about 10% of the new products and processes in high-technology US industries (E Mansfield, 1991). But in the last few decades the universities role in its innovation system is becoming more and more apparent. The main modern interactions between industry and the academic sector have been identified by Debackere and Veugelers (2005). These interactions involve (1) the creation of spin-offs (creating new ventures using academic knowledge), (2) collaborative research, (3) contract research, and (4) the development of Intellectual Property Rights (Universities using patents to commercialize their knowledge).

It is clear that universities play a central role in Regional Innovation systems. Research shows that a firms innovative performance is higher when they are close(r) to major universities (Acs, Audretsch, Feldman, The, & May, 1994). Another study has found that opening a new school leads to a seven percent increase in patent applications by firms in the region (Cowan & Zinovyeva, 2013). The study suggests that the reason for this was mainly the high quality scientific research that was brought to the region. Some researchers even argue that the modern university evolved to become an “Innovation Hub”(Youtie and Shapira, 2008). As can be seen in Figure 3, the traditional university was merely seen as a storehouse of knowledge, the present university is a knowledge factory, and the evolving university is one where knowledge is not only created, but also diffused and used. This theory is in line with theories of universities playing a more intense role in engaging with its economic environment.

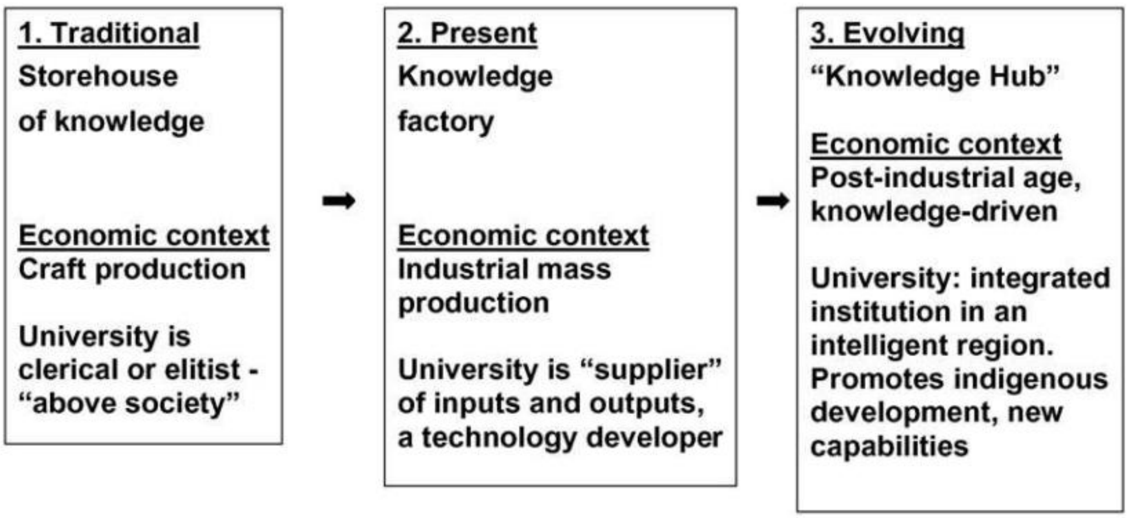


figure 3, the evolving university (Youtie & Shapira, 2008)

2.3 ACADEMIC COMMERCIALIZATION IN EUROPE

Investopedia (2016) describes commercialization as:

“The process by which a new product or service is introduced into the general market.”

The website of Dictionary (2016) describes commercialization as:

“To emphasize the profitable aspects of, especially at the expense of quality”

Since universities produce knowledge, this could be seen as one of their “product offerings”. The second definition adds purpose to commercializing by putting emphasis on the profitable aspects. Perkmann (Perkmann et al., 2013) makes a distinction between academic engagement and academic commercialization.

He has defined academic engagement as all the activities involved in academic-industry knowledge transfer. In addition, academic commercialization is defined as intellectual property creation and academic entrepreneurship (Perkmann et al. 2013). We would like to broaden this definition by including all processes the university can utilize to valorize their "products". The following definition of Academic commercialization will be used in this thesis:

"Academic commercialization are activities by which a University emphasizes on the profitable aspects of academic-industry knowledge transfer"

As universities are viewed as important drivers of economic growth (Etzkowitz, 2002; Edwin Mansfield & Lee, 1996), research on how to manage university knowledge spillovers has become a much studied issue in the research towards technology transfer. Next to TTO's, science parks and other incubators, universities have also been creating internal supportive rules and procedures to promote commercialization (Jensen & Thursby, 2001). Internal university valorization centers and holdings handle university Intellectual Property Rights (IPR) and support start-ups financially, but also provide them with legal and strategic advice.

A lot of research on university commercialization has focused on the various methods a university can utilize to commercialize their inventions or technology (Breznitz, O'Shea, & Allen, 2008; Kroll & Liefner, 2008; Maia & Claro, 2013; Shane, 2002; Siegel et al., 2007). Scholars have identified a range of factors that led to successful academic technology transfer. The quality of a universities basic research endowments is one of them (Powers and McDougall, 2005), as well as the Universities prestige (Sine et al., 2003), and also organizational practices and the funding of Technology Transfer (Siegel et al., 2003).

In the US, academic commercialization first became a research topic since the Bayh-dole act that allowed universities to commercialize their knowledge using IPR (Mowery et al., 2001). In the early 2000's, after the appearance of the studies documenting the growth of patents by US universities, Europe started researching the commercialization of their universities with a research stream called Academic Patenting in Europe (APE) (Geuna & Nesta, 2006; Lissoni, 2013). This research was focused on using patenting data to learn more about the European paradox, which stated that European universities were far behind compared to US ones in terms of commercialization output. Even though not quite as many patents were filed by European universities, it appeared that European professors were in fact using IPR to commercialize their findings throughout the late nineties and early twentieth century's. It was because of two reasons that their universities did not partake in commercializing through patents. Firstly, the "professor's privilege" was active in IP legislation in several countries. This meant that academic personnel were exempted from disclosing their inventions to their employers. And Secondly , European Universities were less financially and managerially autonomous than US universities (Thomas & Nokkala, 2009). This is why European universities did not have the incentives, skills and tools to commercialize their employee's inventions. Academic scientists were advised to commercialize their own inventions by patenting it on their own name or selling their IP to businesses.

Further research then resulted in finding that at least in terms of relative contribution to domestic patenting, the gap between US and European academic patents is very small (Lissoni, 2012). Lissoni (2012), proved this by changing the definition of an academic patent. Beforehand, an academic patent was defined as a patent owned by a university. However, when looking at the patents owned by academic inventors, he (2012) found that the gap between US and European universities wasn't all that big. Figure 4 shows the different definitions of an academic patent. On the left side are only the university owned patents, the right side also includes private patent applications by academic inventors. It is obvious that US Universities are patenting much more than European ones when we only look at the University owned patents. However, the right side of the table shows that these European countries come very close to the US amounts of academic patents. We can even see that Sweden excels the United States by a 0.2%. However, even if European Universities are catching up patent-wise, our commercial performance is still lower than that of US Universities. European Universities still seem to have trouble commercializing this Intellectual Property (European Commission, 1995).

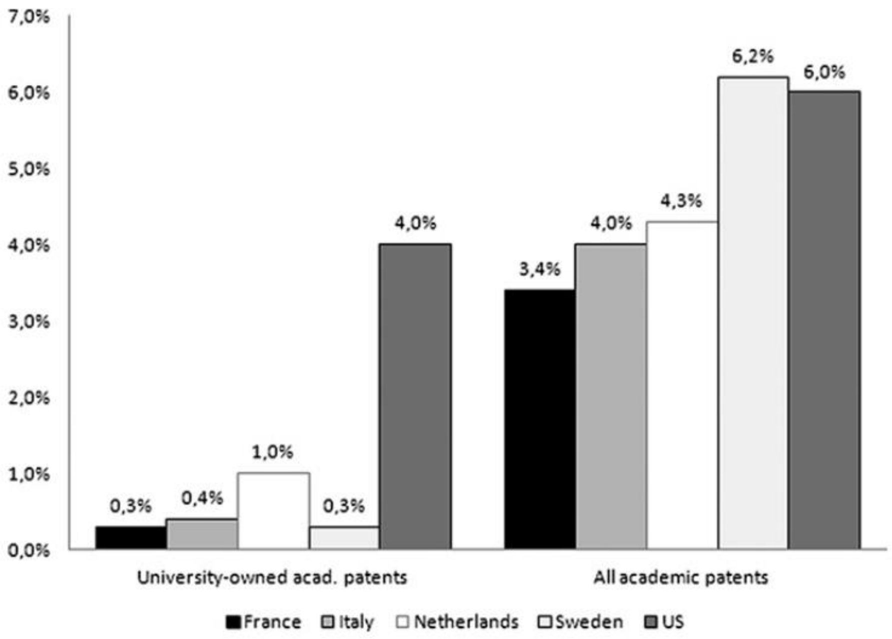


figure 4, Defining academic patents (Lissoni, 2012)

In this thesis we are not comparing US Universities with European ones, however it is still valuable for us to keep the difference in mind between these Universities structures and how they deal with commercialization. The most influential US universities are private institutes, but the US also holds many publicly funded universities, called state universities. European universities are often public institutes. In the Netherlands, there are only three exceptions to this rule. The Netherlands holds 21 universities, 18 of which are public institutes. Private institutes include the Dutch Defense Academy, and two business schools called the Nyenrode Business University and the TIAS School for Business and Society.The biggest difference between a private and public institute is the way they are funded. Public institutes are mostly funded through the state, whereas private institutes are responsible for their own funding. This results in private institutes charging high tuition fees, in exchange for more personal student guidance. This also results in a more commercial focus in the universities strategy.

European universities used to have two main goals; Education and research. However, Public institutes are being forced to partake in commercial activities as well, mainly due to declining subsidiaries from governments. Recent changes in European policy aim at increasing commercially oriented activities in academe (Czarnitzki, Hussinger, & Schneider, 2011). This “Third mission”, as it is described in literature (Casper, 2013; Paleari et al., 2014; Perkmann et al., 2013) can also be seen in the Netherlands. Some Dutch Universities are commonly referred to as “Third Generation Universities”(Duke, 2009; Wissema, 2005). The 3GU is a university with a third mission, commercialization. Wissema talks about the changing University model, and the growth from the science based university to the Third Generation University (3GU). Several reasons were presented that propelled this change. Firstly, top universities want to carry out cutting-edge research and need additional funding, as the costs are higher than the budgets provided by governments. This incites them to collaborate more with technology-driven industry. A second force is the fact that technology-driven enterprises are seeking more collaboration with universities to work on scientific research projects that they consider vital to their strategy. In Europe and the Netherlands in particular, this results in the worlds of academic and industrial research to come closer and closer. Still, private institutes will probably always stay more focused on commercialization and profits, since this is in their strategic existence. Still, they will not likely be far ahead of public institutes that take their third mission seriously.

2.4 INNOVATOR NETWORKS, INNOVATION AND ACADEMIC COMMERCIALIZATION

Collaborative networks are extremely important to innovation (Motohashi, 2005). A study by Defazio and his colleagues (2009) have found a significant positive impact on the productivity of academic researchers after an increase of collaborations within a network. He argues though, that the productivity only is increased in the long run, for he found no short term results. Fleming (Fleming et al., 2007) studied innovator networks and calls them “small worlds of inventors”. He used a patent database to structure inventor networks from over 2.8 million US patents. In this network there were over 2 million unique individual inventors identified. Then the effects of these collaboration networks on regional innovation output were explored. This study failed to find hard evidence that inventor network clusters had a positive effect on innovative productivity within the region. However, he did find a correlation between increased innovation output and larger connected components with shorter ties between inventors. A shorter path length means that there are fewer steps required in a network before reaching a certain node. This research therefore suggests that a network that is denser, with a larger main component (the biggest connected component in the network) is likely to have an increased innovation output over a region that is less connected.

Economic sociologists argue that strong social networks at both the individual and organizational level have great impact on firms within science based industries (Porter et al., 2005). One particularly interesting article introduces a different perspective on university commercialization. Casper (2013) argues that the quality of a universities Regional Innovation System (in the article referred to as regional environment) can significantly impact the universities success in commercializing knowledge. As most articles emphasize the universities “push” variables, he stresses the importance that a “pull” from the universities environment can be equally important.

Casper contributed to this theory by finding that the presence of strong social networks between inventors had a positive effect on the local universities commercialization output. He used patenting data from 20.000 patents from the Los Angeles and San Francisco regions to examine the quality of social ties between industry and university scientists. Networks were created out of the biotechnology patents from the 1980-2005 periods and he found that universities in San Francisco have a higher commercialization output than universities in Los Angeles, which correlates with a more cohesive inventor network between industry and university scientists in this region. This thesis will try to contribute to- and expand this theory, using 2 (smaller) Dutch regions and their respective universities.

3 RESEARCH METHODOLOGY

This study investigates the impact of the regional inventor network from every technology field on the universities commercialization output. Patent data on the size, overall connectedness and connections between academics and industry is compared to the commercialization output of the universities in these regions. This study will compare data from the years 2000-2010. Universities have been patenting in the US since the beginning of the Bayh-dole act, in 1980. In Europe however, in the mid 1990’s, governments started to actively support the “third mission” activities. In England for instance, main policy instruments in were schemes for entrepreneurial funding and a “third stream” funding for knowledge transfer activities (Meyer & Tang, 2007). Other European countries like Germany, Norway, Sweden, Italy, France, Spain and Denmark followed with activities much like these (Geuna & Rossi, 2011). In the Netherlands, IPR policy allows universities to be the owner of their employees IP since 1995. We have chosen to gather data from the years 2000-2010 because of these years provide us with reliable data. Looking at the patenting data from the EPO

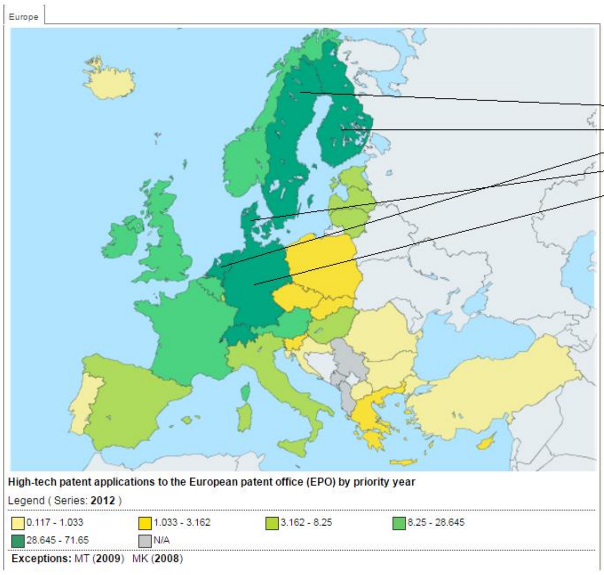
(European Patent Office), many Dutch universities started patenting from the year 2000. Data beyond 2010 could be unreliable because the EPO takes up 3-4 years to process a patent application (EPO, n.d.). Thus it is likely that the period between 2010-2015 contains patents that have not yet been granted by the EPO.

3.1 THE DUTCH NATIONAL INNOVATION SYSTEM

Even though the Netherlands produces a fair amount of patents, it is said that the Dutch innovation policy has a central problem that is called the Dutch Innovation Paradox. The Netherlands is strong in production of scientific knowledge and patents, but weak in commercialization and application of this knowledge (EDZES, 2010). This provoked a discussion about how innovation should be stimulated in the Netherlands. More transparency and openness is proposed in the recent paper presented to the European Commission. Different possibilities of improvement are presented:

- Stimulating innovative SMEs
- The attractiveness of the Netherlands as a location for knowledge intensive activities
- Innovation through strong and internationally leading innovation clusters
- Establishing an excellent climate for both learning and research

Even though the Netherlands seems to be having a hard time commercializing knowledge, the country scores fairly high on the innovation charts. Within Europe, the Netherlands is on the third place of all European countries in scoring the highest amount of high tech patent applications. In figure 5 you can see the amount of high tech patent applications in 2012 in Europe.



TOP 5	European country	High-tech patent applications to the EPO per 1 million inhabitants
# 1	Sweden	71,6
# 2	Finland	66,4
# 3	Netherlands	32,6
# 4	Denmark	31,7
# 5	Germany	2,.9

Figure 5, High-tech patent applications to the EPO in 2012. Source: http://ec.europa.eu/eurostat/

3.2 REGIONAL INNOVATION SYSTEMS IN THE NETHERLANDS

Two Dutch regions will be compared, the Twente region and the Delft region. These regions were picked for several reasons. First of all, research towards the effect of a regional innovation system on academic commercialization has not yet been done in Europe, let alone in the Netherlands. Since this research is based on patenting data from the EPO, the Netherlands is a fine pick to represent an innovative country from Europe.

The Delft region is in the Provence of Zuid-Holland, and the Twente region is in the Provence of Overijssel. In figure 6, it is visible where these regions, which are surrounding a University, are located on a map of the Netherlands. It is also clear that the provinces (also NUTS 2 regions) in which Twente and Delft reside, both score between 42,6% and 52,9% in terms of Human resources in science and technology.

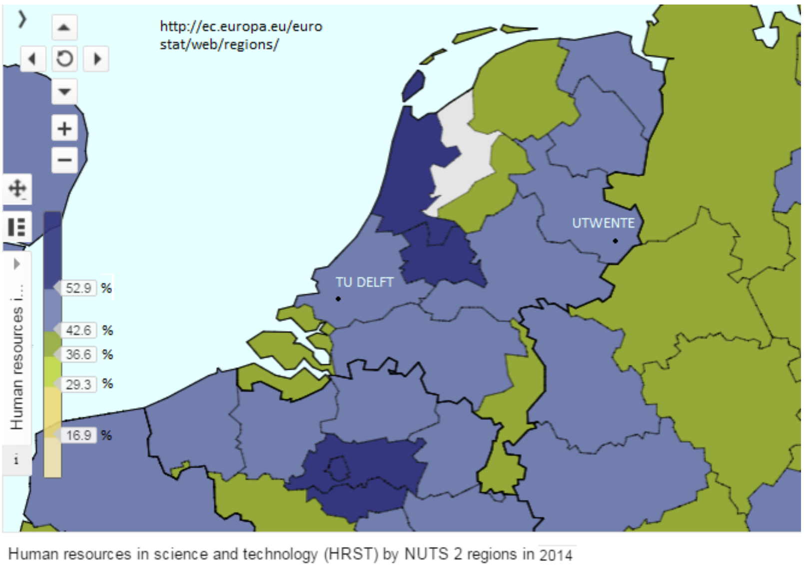


Figure 6, Human resources in science and technology in 2014 . Source: [http://ec.europa.eu/eurostat/cache/RSI/" \l "?vis=nuts2.scitech&lang=en"](http://ec.europa.eu/eurostat/cache/RSI/)

Another measure for innovation is the employment in high tech sectors. Both Provinces score average on this measure. Zuid-Holland has 3,7% of the total employment in the high-tech sector, and Overijssel scores a 2,7%. This is made visible in figure 7, which shows data from the year 2014. In terms of R&D expenditure the Delft region also scores a little higher than the Twente region.

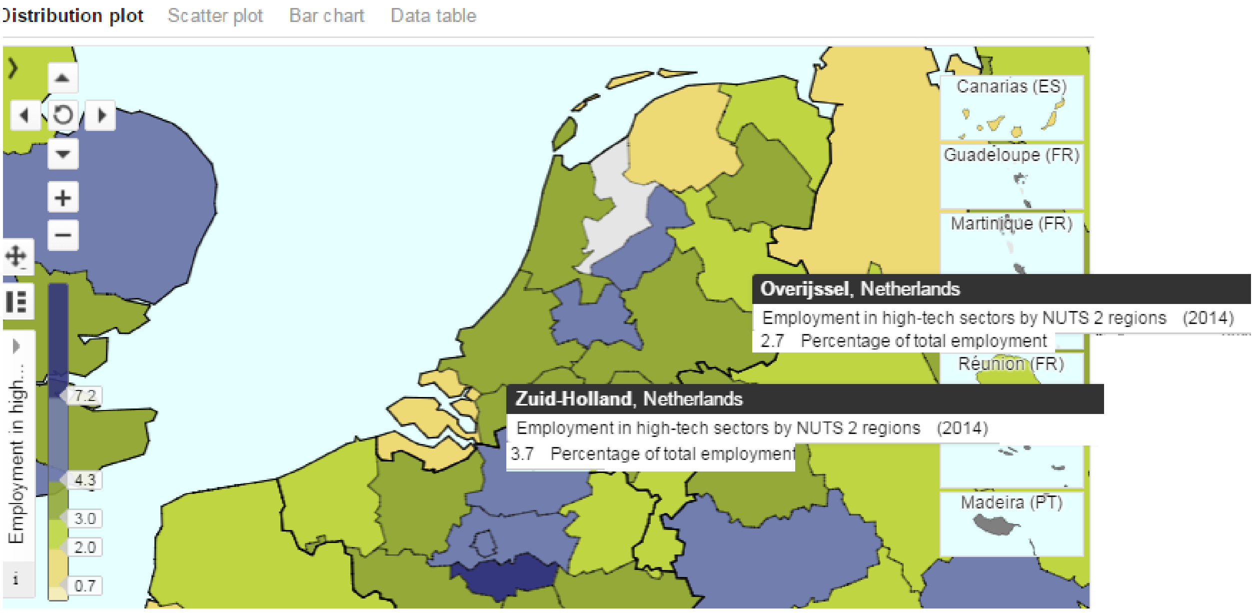


Figure 7, Employment rate in high-tech sectors by NUTS2 regions (2014)
Source:http://ec.europa.eu/eurostat/cache/RSI/#?vis=nuts2.scitech&lang=en

In figure 8 the data for the year 2012 on R&D expenditures is shown per Provence. The Overijssel Provence, which hosts the Twente area, spends 1.6% of GDP on Research and Development. The Zuid-Holland Provence, which hosts the Delft area, spends 2% of GDP on Research and development, which is slightly higher. More specific data on Twente and Delft region's innovation will be extracted from patenting data and this will be presented in the results part of this thesis.

Country profile Key indicators Nederland		R&D expenditure	
		Level	Distance to target
		% of GDP	% of GDP
Regional Europe 2020 indicators		2012	2012-2020
EU28		**2.0**	**1.0**
Nederland		**2.0**	**0.5**
NUTS 1 regions			
NL1	Noord-Nederland	1.2	1.3
NL11	Groningen	1.8	0.8
NL12	Friesland (NL)	1.0	1.5
NL13	Drenthe	1.3	1.2
NL2	Oost-Nederland	2.0	0.5
NL21	Overijssel	1.6	0.9
NL22	Gelderland	2.3	0.2
NL23	Flevoland	1.7	0.8
NL3	West-Nederland	1.9	0.6
NL31	Utrecht	2.1	0.4
NL32	Noord-Holland	1.8	0.7
NL33	Zuid-Holland	2.0	0.5
NL34	Zeeland	0.8	1.7
NL4	Zuid-Nederland	2.5	*
NL41	Noord-Brabant	2.8	*
NL42	Limburg (NL)	2.0	0.6

less developed regions *(only NUTS2 and NUTS3 regions are colour code* *
transition regions

Figure 8, R&D expenditures in the Netherlands, Source: (European Comission, 2015)

From a research design perspective these two regions were chosen because they both have technical universities with a lively surrounding science park. This is essential if we want to compare the region's innovator networks to the University that resides in the region. TU Delft (Delft University of Technology) and UTwente (University Twente) are very much alike and have many overlapping research fields. Both universities have faculties for technology management, industrial design, electronics, math, informatics, Geo & earth sciences, and applied sciences. The only faculty wise difference is that TU Delft also has faculties for maritime, air and space sciences.

	Government grants (Mil. €)	Support PERS.	Scientific PERS.	Students total
TU Delft				
2008	343	1878	3113	15174
2009	353	2008	3128	16265
2010	318	2001	2917	16899
UTwente				
2008	180,4	1207	1597	8245
2009	193	1292	1743	8416
2010	189,8	1432	1837	9002

Table 1, Comparable data on university size (Reports, 2010)

The relative size of TU Delft is around twice the amount of UTwente. The difference in size can be seen in Table 1 and in figure 9, where the yearly government grant, amount of support personnel, scientific personnel and the amount of students are portrayed. The extra faculties of TU Delft result in a higher student total, which on its turn results in a higher government grant, since this is highly dependent on the amount of students the University holds. The relative size must be taken into account when calculating the commercial performance of each university.

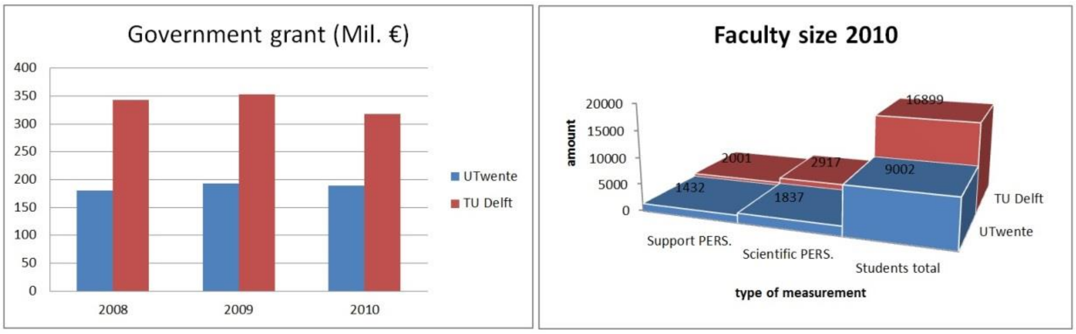


Figure 9, Size of universities

TU Delft and UTwente are both surrounded by science parks. A science park is a region that is designed to promote innovation. These regions support triple helix activities and often offer a number of shared resources like incubators. The incubators for our researched regions are YES!Delft[3] and Kennispark Twente[4] and are both very active in academic technology transfer and valorizing its universities knowledge. Firms that are drawn to these science parks are often firms that invest in R&D, who are more likely than other firms to draw from universities (Laursen & Salter, 2004). In a Japanese case study, evidence was found that smaller firms achieve higher productivity through University Industry Cooperation (Motohashi, 2005). Among other reasons, and the fact that university spin-offs often are positioned close to their university, the Delft and Twente science parks are packed with innovative technology SME's. These firms are often dependent on IPR, marketing a new product or service, which makes a good case for a study based on patenting data.

[3] http://www.yesdelft.nl/

[4] http://www.kennispark.nl/

3.3 MEASURING UNIVERSITY COMMERCIALIZATION

To measure differences in academic commercial performance we will look at several important variables. Following Casper’s research, university patenting will be the primary indicator of commercialization output. For this variable, all the patent applications in the EPO database, under the name of the university will be used. This data is publicly available and all patents include the application year, which allows the data to be examined on a year-by-year basis before correlating it with the inventor network on that specific year. However, some weaknesses can be identified when using patents as a primary indicator. One potential weakness could be that the universities IPR policy can have impact on whether they apply for a high or low amount of patents. Casper (Casper, 2013) also identified two main weaknesses. The first issue is that a large number of academic patents fail to find commercial licensees. Research proved that only 51% of MIT patents were under license (Shane, 2002), and for other universities this could potentially be as low as only 30%. The second issue is that some patents could generate millions of Euro’s in income while other patents only cost the university money.

This is why, in this thesis, also the universities licensing income in included is measuring the universities commercial success. Casper discussed that the amount of licensing deals or the amount of licensing revenue would also be a good measure, but he is unable to use this in his research because historical data is not publicly available for many of the US universities. Fortunately, Dutch universities are forced to differentiate in their yearly reports between three different income streams. The (1) first income stream is directly from the Ministry of Education, Culture and Science. The (2) second income stream comes from independent public organizations, and the (3) third income stream is project – and license- based funding , often from private institutions. This could also include income from holdings and patent licenses or sales. Therefore, the third income stream will also be used as the second commercialization variable.

University spin-offs have been identified as an effective means of technology commercialization for universities (Kroll & Liefner, 2008). Next to the fact that they are a contribution to the regional development, they can also can be financially beneficial for universities (Bathelt, Kogler, & Munro, 2010; Breznitz et al., 2008). Therefore, the amount of university spin-offs will be used as a third measure of academic commercial success.

3.4 INVENTOR NETWORK CREATION

The purpose of social network analysis is creating more insight in how the inventors in a specific region are collaborating with each other. The size and density of the network can bring forth meaningful results when aligned with the academic commercial output in the region. We mainly want to see how many inventors the region hosts, and the analysis will provide us with insights on how closely they work together. Ties between inventors are frequently documented through patent applications or scientific publications. The method used (Casper, 2013) in this thesis will draw on Fleming’s(Fleming et al., 2007) method, also more recently used by Steven Casper. However, due to differences between the US patent database and the European database we were forced to slightly deviate from these methods.

The EPO PATSTAT Spring 2015 database (Lissoni, 2012) was used to create yearly networks from 2000-2010. This database is highly up to date, as it is updated every 6 months by the EPO. However, there is still a slight chance that patents between 2010 and 2015 are issued after Spring 2015, thus these years are not included in the analysis. Every patent application includes an owner name and address, and (at least one, but mostly several) inventor names. The US database also stores addresses for inventors, but the PATSTAT database does not. Originally we would include all the patents of which at least one inventor resides in the chosen region.

However, due to the lack of inventor addresses, in this research, we used the address of the patent owner. Thus, if the owner of the patent resides in the region, the patent is included in the analysis.

A total of 2306 patents were drawn from the database, 2071 of which are from the Delft region, and 235 are from the Twente region. From these patents we were able to draw 1817 unique inventors from the Delft region, and 586 unique inventors from the Twente region, resulting in a total of 2403 unique inventors. A co-inventor tie is created when patents have listed multiple inventors. Inventors working together on issuing a patent have a social connection. If one of the inventors then works on another patent, his co-workers have an indirect connection with his former team, creating a social network. Once a link is created, it is estimated to last for 5 years (Fleming et al., 2007). Figure 10 displays how social networks are formed from patent applications. Person A has been involved in 2 patent applications in the last 5 years. Both teams are connected with their own team members, and through person A they are connected to the second team. This final network involves 5 unique inventors, and 6 total social ties. An example query for extracting data on the Delft region for 2010 can be found in appendix one.

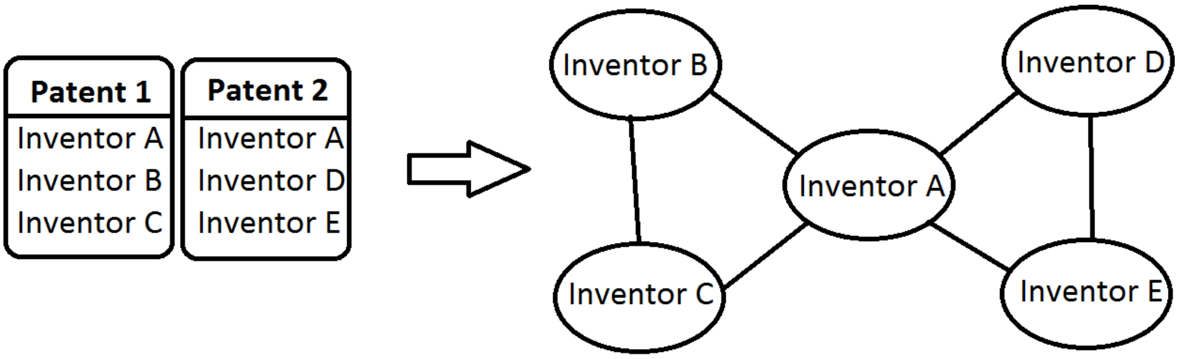


Figure 10, Example of social network creation

There were some academic harmonization efforts on the EPO database, to make the data more easy to use for research purposes. However, the data is still very rough. The same inventors are in the database under different names and different id's. Scripts in Microsoft excel were used to harmonize the link-lists and prepare them for the networking software.

The software by Gephi and his colleagues (2009) was used for mapping the networks. Using the Yifan Hu algorithm (Gansner, Hu, North, & Scheidegger, 2011) enables us to create a clear view of the networks. For example, figure 11 is a representation of the Delft inventor network of 2010, it contains 930 inventors and 1790 connections. You can see an interconnected separate network in the middle of the image, which is called the main component. In this case, the Yifan Hu algorithm draws separate smaller components (inventions or inventor teams), which are not connected to the main component to the outside of the visual representation.

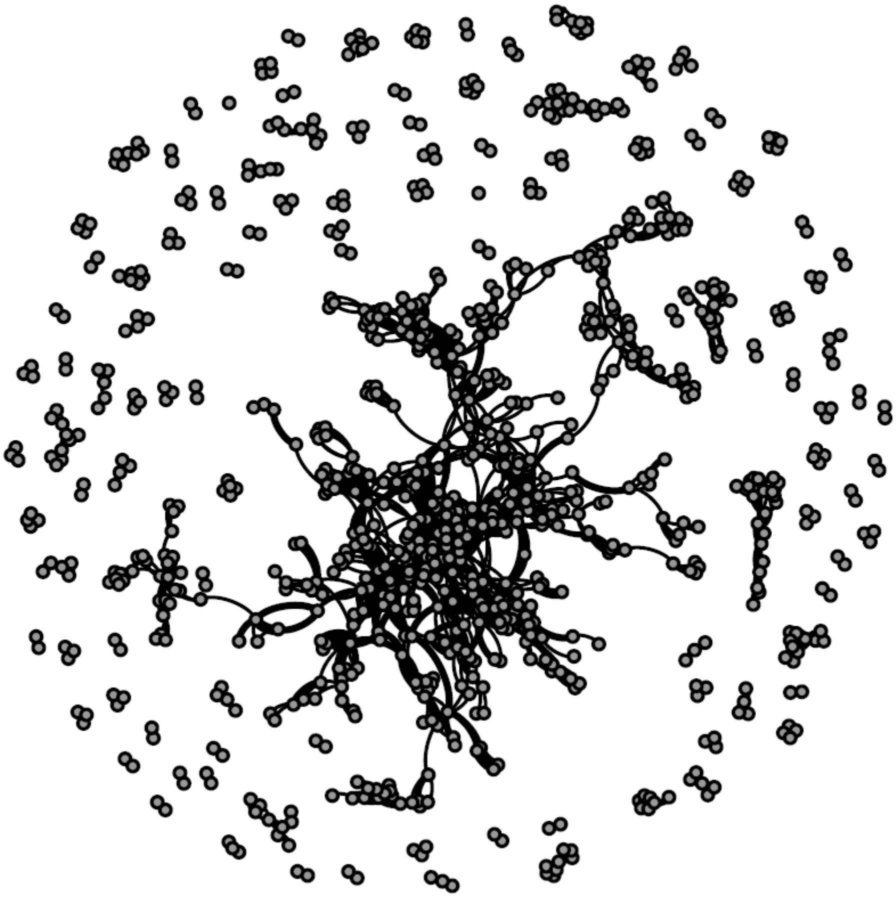


Figure 11, Delft Inventor network 2010

3.5 IDENTIFYING ACADEMICS

To gain additional insights in the social dynamics of the Delft and Twente networks, the academics are also identified. This provides us with data on how many academic inventors are present in the network and in the network main component. This also provides us with data on how many links there are between industry and academics. For research purposes we defined an academic inventor as follows:

An academic inventor is an inventor who –at the time of participating in a patent- also is in employment at a University. This could be as a PhD candidate, professor or visiting professor, at any University. A manual background resume check was performed on all inventors. Inventors went through several checks using Google, LinkedIn, and scientific publications to determine whether they were academics at the time of filing the patent in which they are involved.

We performed a random check on 20 university owned patents, and found that all participating inventors were employed academics. So firstly, the EPO database was used to check if inventors participated in a university owned patent. Any inventors who cooperated on university owned patents, could then be labeled as academics.

For all the remaining inventors, we then performed a social network check on LinkedIn. If the inventor was working for a university at the time of the patent application(s) he or she was involved in, the inventor would be labeled as an academic. If the inventor was employed by industry at the time of the patent application, he or she would be labeled as industry.

At this point, only Inventors who did not participate in university owned patents, and inventors who do not own a LinkedIn account remained to be checked. The next step was to search for additional information about the inventor on internet search engines like Google. Sometimes a Google search would lead to a university website, where academic activities could lead to the inventor being an academic. Other times a Google search would lead to information about the individual on a corporate website.

However, if this check also did not pose any results, the inventors name would be run through the last check. This check involved a publications check on Web of Science (WebofScience, 2016) and Google Scholar (Scholar, 2016). If a publication could be found with the inventor as an author during the time of the patent application, the article(s) were requested and opened. Many times the institute of an author can be found in the article, and this way we were able to identify whether the inventor was from an academic institute or industry.

If LinkedIn and the search engine search would pose no results, and the individual also did not have any publications on his/her name, we concluded that the inventor cannot be an academic. And therefore would be labeled as an industry professional. Figure 12 on the next page displays the decision tree that was used for identifying academics.

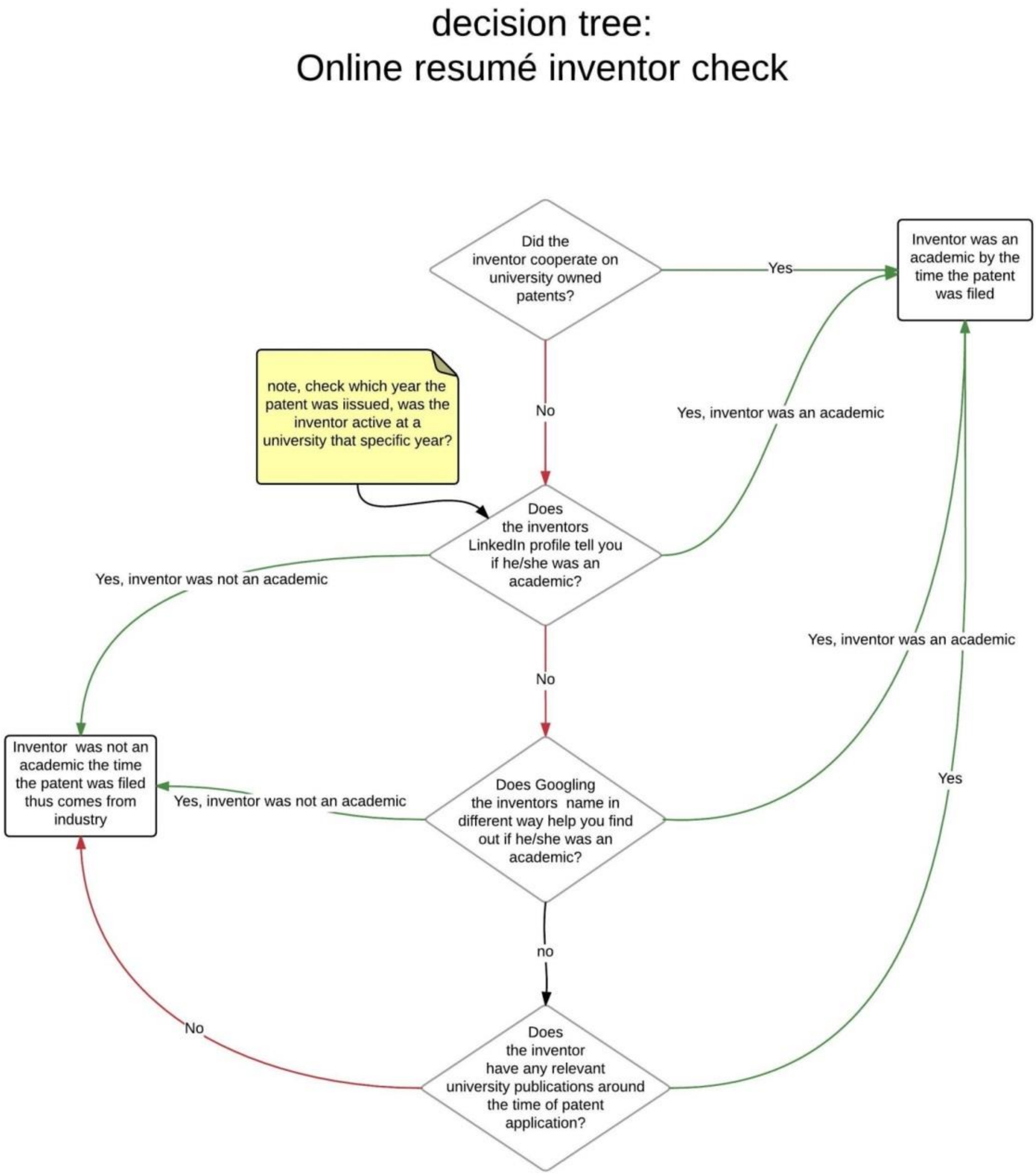


Figure 12, Online resume check decision tree

4 RESULTS

The results are presented in four different subchapters. The first section uses descriptive statistics to determine the different Universities commercial output. Secondly, innovator network size and connectedness are compared for the Delft and Twente regions. The third section will provide data on the network main components, and lastly the academic industry links are discussed.

4.1 ACADEMIC COMMERCIALIZATION

The amount of patent applications will be used as a primary measure of commercial success. Besides this, the third income stream data on and spin-offs will also be used. Information on patent applications was gathered from the PATSTAT European Patent Office database. Data on universities third income streams is collected from yearly reports. Initially, most of this data could be found on the universities websites. However, universities did not report back to the year 2000 in the website reports, so reports on this data were manually requested at the university administrative offices. Yearly data on spin-offs proved the hardest to acquire. For the TU Delft, we were able to find information on spin-offs in some of the yearly incubator reports (YES!Delft). For the University of Twente we were only able to find data from 2008-2010. This data could still be inaccurate, due to the fact that universities are not aware of the many university related start-ups that could be founded without the university or incubators knowledge. In addition, some of the tenants of universities' incubators, do not commercialize universities' patents or their researches' outcome. We also noticed that some incubators and universities have a different interpretation of the word Spin-off. Typically a spin-off would be a start-up company that utilizes universities Intellectual Property. However, some universities interpret a Spin-off as being a start-up that utilizes a certain (unpatented) knowledge or expertise. The results are presented in four different subchapters. The first section uses descriptive statistics to determine the different Universities commercial output. Secondly, innovator network size and connectedness are compared for the Delft and Twente regions. The third section will provide data on the network main components, and lastly the academic industry links are discussed.

Table 2, Academic commercialization, Spin-offs & IS. Sources: (1) PATSTAT online EPO database (2) Universities and incubators yearly reports, available upon request.

	Patent applications (in EPO)(1)		3rd Income Stream (Mil. €)(2)		Spin-offs(2)	
	TU Delft	**UTwente**	**TU Delft**	**UTwente**	**TU Delft**	**UTwente**
2000	15	2	56,2	23,9	8	
2001	9	3	55,4	25,8	10	
2002	13	1	63,6	27,1	9	
2003	16	6	56,7	28,8	8	
2004	24	1	63	30,6	-	
2005	19	4	66,3	29,9	38	
2006	20	5	77,3	31,1	53	
2007	26	2	81,3	49,9	56	
2008	24	4	99,5	47,3	72	55
2009	10	3	109,3	58,7	86	82
2010	10	13	111,7	56,2	105	76
Total	186	44	840.3	409.3	-	-

A summary of the data on the three measures of commercialization between 2000 and 2010 can be found in table 2. Since TU Delft is about twice the relative size of UTwente, we would also expect the commercial statistics to be of twice the size. As seen in figure 13, the third income stream fits this expectation. In 2006, TU Delft receives two and a half times the income of UTwente. For 2003, 2007, 2008 and 2009 TU Delft receives slightly less than two times the amount of UTwente, and over all the rest of the years they receive slightly more than two times UTwente's third stream income. This results in Delfts total amount of third income stream to be slightly higher than double the size of the total third income stream from UTwente.

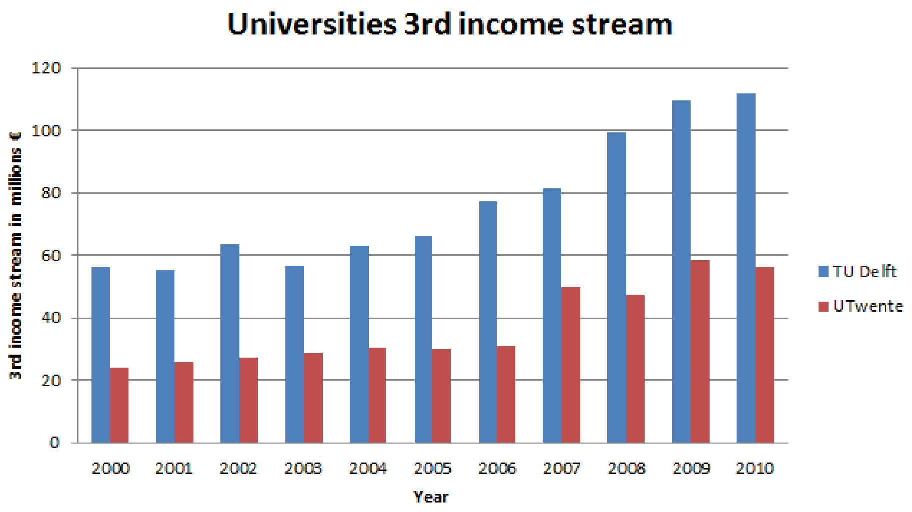


Figure 13, Universities 3rd income stream

Both third income streams show a gradual growth between the years 2000 and 2010, with TU Delft growing from 56,2 million to 111,7 million, and UTwente growing from 23,9 million to 56,2 million income. Both universities manage to double their third income profits over these 11 years.

the second measure, the amount of patent applications shows very different results. The amount of total patent applications by TU Delft (186) is more than four times the size of UTwente (44). Figure 14 shows the cumulative patent applications over the years, by both universities.

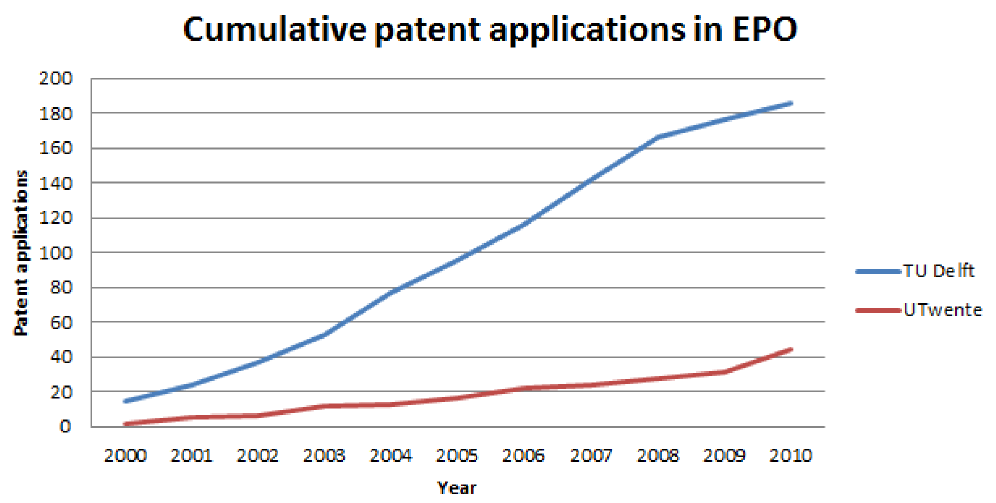


Figure 14, Cumulative patent applications in EPO

Both universities show a steady growth in patent applications. TU Delft shows a strong yearly growth from 2002 until 2008, growing from 15 yearly patent applications to 24. In 2009 and 2010 there is a slight drop in Delft's patent applications, resulting in 10 patents for each year. TU Delft applies for an average of around 17 patents per year. The data on UTwente also shows a steady growth with an average of 4 patents per year, over all UTwente applies for fewer patents than TU Delft during 2000 until 2009. The year 2010 is the only year in which patent applications by UTwente exceed those of TU Delft, with a total amount of 13 patent applications versus 10. From these findings we can confirm that TU Delft relatively produces about double the amount of yearly patent applications compared to UTwente.

4.2 NETWORK SIZE

Our main hypothesis in the research is that a bigger inventor network leads to more academic commercial success. Thus, we expect the Twente inventor network to be considerably smaller than the Delft network. Looking at sheer size, our finds support for these predictions. The Twente network for 2010 is visually presented in figure 15, using the Fruchterman Reingold algorithm (Fruchterman & Reingold, 1991). This allows us to see that not only the network is considerably smaller than the Delft network (Figure 15), but it also shows the lack of a (big) network main component. This network contains only 192 inventors, and 326 connections, which is considerably smaller than Delft's 920 inventors and 1790 connections.

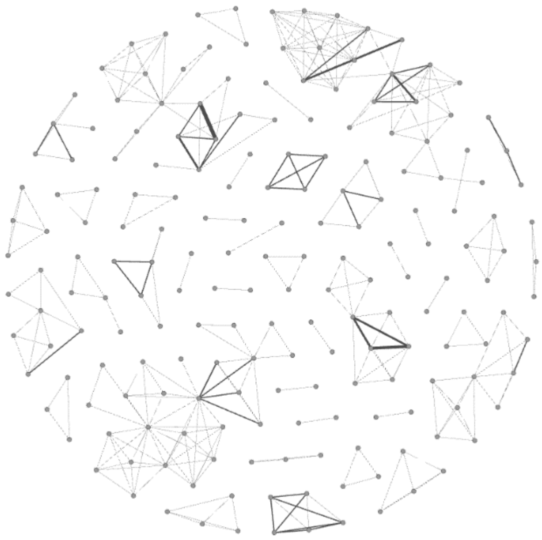


Figure 15, Twente Inventor network 2010

In addition to the visual representation, descriptive statistics on the size of the networks from 2000 to 2010 are displayed in table 3. This table shows the number of inventors in the networks, as well as the amount of connections that connect the inventors. It is visible that not only in 2010, but during all the measured years the Delft inventor network has been considerably larger than the inventor network in Twente.

Table 3, size of Delft and Twente inventor networks

	Nr. of inventors in network		Nr. of connections in network	
	Delft	**Twente**	**Delft**	**Twente**
2000	398	46	575	48
2001	388	55	556	57
2002	391	57	577	48
2003	479	57	711	48
2004	605	54	958	47
2005	685	73	1132	71
2006	760	90	1299	89
2007	858	111	1594	124
2008	927	134	1781	206
2009	958	156	1884	239
2010	930	192	1790	326

Both networks, however, dramatically increase in size during the 2000-2010 time periods. This growth is visualized in figure 16. The Delft regional inventor network grows to be more than twice its size in 7 years, from 398 inventors in 2000 to 858 in 2007. In the following 3 years the Delft network grows another 8%.

The Twente network even grows to three times its former size. By 2005 it has almost doubled in size from 575 to 1132 inventors, and in the following 5 years it grows again by another 58%.

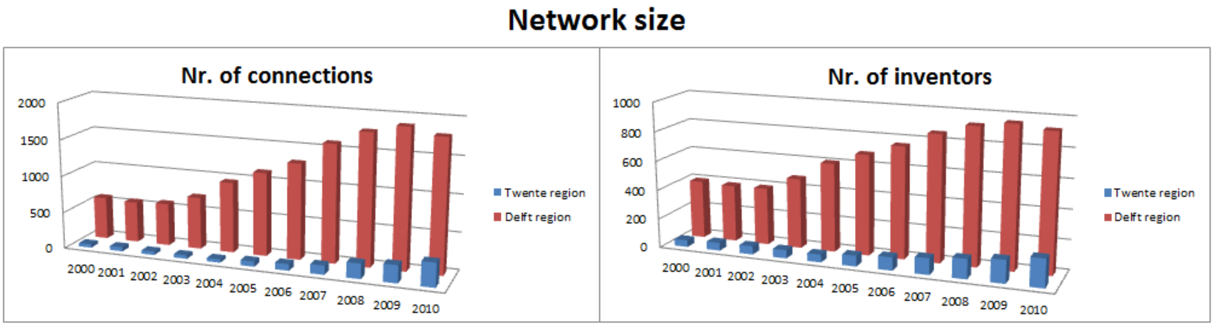


Figure 16, network size Twente and Delft region

4.3 THE NETWORK MAIN COMPONENT

Fleming found that areas with the largest connecting component had increased innovation (Fleming et al., 2007). It is therefore understandable that this main component is often used in social network analysis. Casper focused only on the main component (MC) data in his research linking innovator networks and academic commercial output (Casper, 2013). But since the networks used in this thesis are relatively small compared to the area's measured in Casper's research, solely using data on the network main components could bring unreliable results.

Table 4 presents descriptive statistics the network MC's of Delft and Twente during the 2000-2010 period. The first column represents the size of the MC in the number of inventors it contains. The second column shows the relative size in percentage. The relative size is the size of the main component compared to the total size of the network. A network with 100 inventors and a main component of 50 inventors has a relative size of 50%. The career trajectory analysis from chapter 3.3 determines whether an inventor is an academic or industry professional. In addition is allows us to determine how many academics were involved in the network main component.

Table 4, Statistics on network main components

	Nr. of inventors in main component		Relative size of the main component		Nr. of academic inventors in main component	
	Delft	**Twente**	**Delft**	**Twente**	**Delft**	**Twente**
2000	55	6	14%	13%	2	0
2001	33	6	9%	11%	2	0
2002	53	4	14%	7%	9	4
2003	78	6	16%	11%	16	4
2004	158	4	26%	7%	29	4
2005	253	8	37%	11%	38	6
2006	288	7	38%	8%	39	5
2007	385	11	45%	10%	35	6
2008	499	14	54%	10%	66	9
2009	562	22	59%	14%	59	12
2010	469	25	50%	13%	33	24

These results are in line with the visual difference in figure 17 and figure 18. These are the main components, extracted from the earlier presented networks in figure 11 and 15. The main component is much smaller in Twente and can sometimes almost be called non-existent. Twente's MC in 2010 contains only 25 inventors, out of the total 192 inventors. Delft has a considerable MC, consisting of 469 inventors in 2010, which is half of the total network inventor's amount.

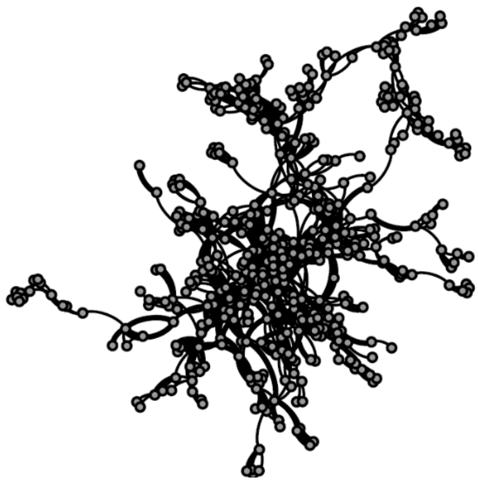


Figure 17, Delft region:

Inventor network main component 2010

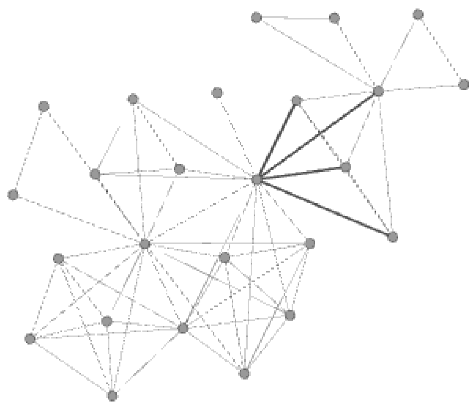


Figure 18, Twente region:

Inventor network main component 2010

In figure 19, data on the amount of inventors in the region's main components is visualized. Delft's main component starts at 55 inventors in 2000, then drops to 33 in 2001, and afterwards grows towards the 562 in 2009. In 2010 the amount of inventors in the main component drops to 369.

The main component of the Twente region starts at 6 inventors in 2000, then remains about the same until 2006, and afterwards we can see a slight growth until 2010. However, this growth is minimal compared to the growth of the Delft main component. The main component in Delft is nine times Twente's size in 2000 (55 vs.6), and almost 19 times bigger in 2010 (469 vs. 25).

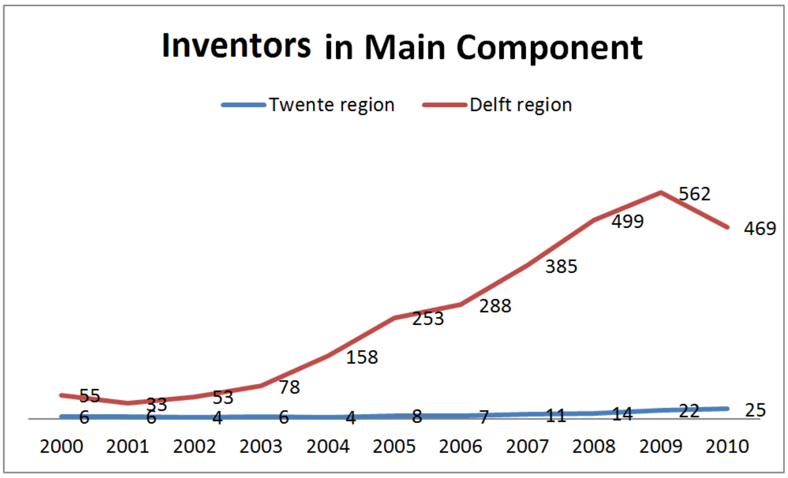
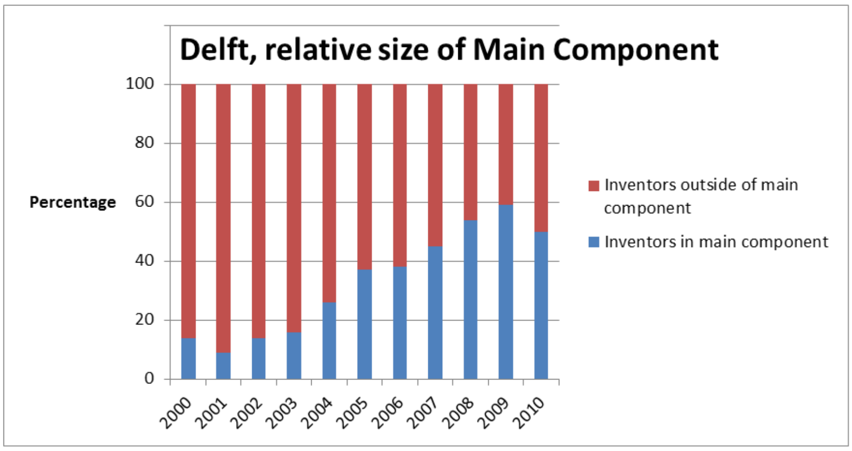


Figure 17, Inventors in main component

The relative size of the region's main components is displayed in figure 20. The data is displayed in a way so we can easily see the size of the main component compared to the total size (100%) of the network. The main component in the Delft region starts out at 14%, then drops to 9% in 2001, for the next two years it stays the same around 15%. From 2004 to 2009 we can see an immense growth to 60%, and then a decline to 50% in 2010. The average relative size of the Delft main component is 33% over the measured timeline.



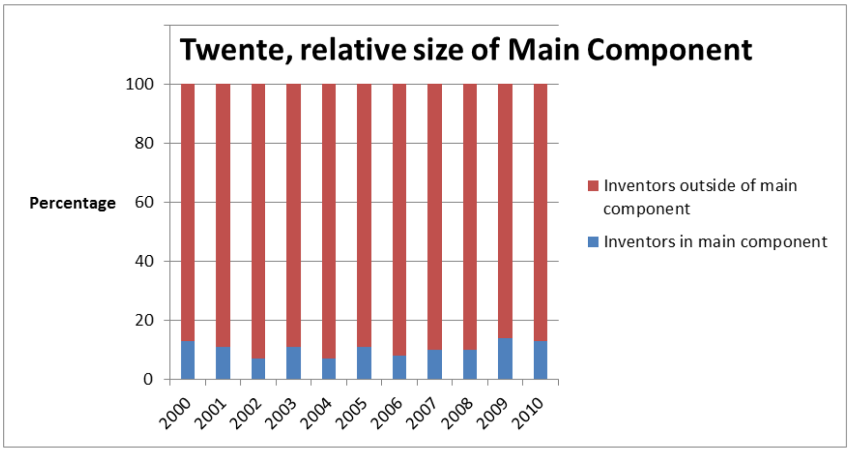


Figure 18, Relative size of network main component

The Twente main component starts at 13% in 2000, and is 13% again in 2010. During the years it fluctuates a slightly, with the lowest point being 7% in 2002 and 2004, and a highest of 14% in 2009. During the years the relative size of the Twente main component has an average of 10%.

The relative sizes of both main components are much alike in 2000, (14% and 13%), but during the ten years of which the data was gathered, Delft's main component grows to be much larger (50%) than the MC in Twente. Also, it is remarkable that the average relative size of the Delft network is more than 3 times larger than the Twente average (33% vs. 10%).

Figure 21 presents data on the amount of academics in the main component. The Delft region shows a steady growth until 2005, then gradually declines over 2 years. Afterwards there is a tremendous increase in 2008 from 35 academics to 66, following a decline in 2009 and 2010.

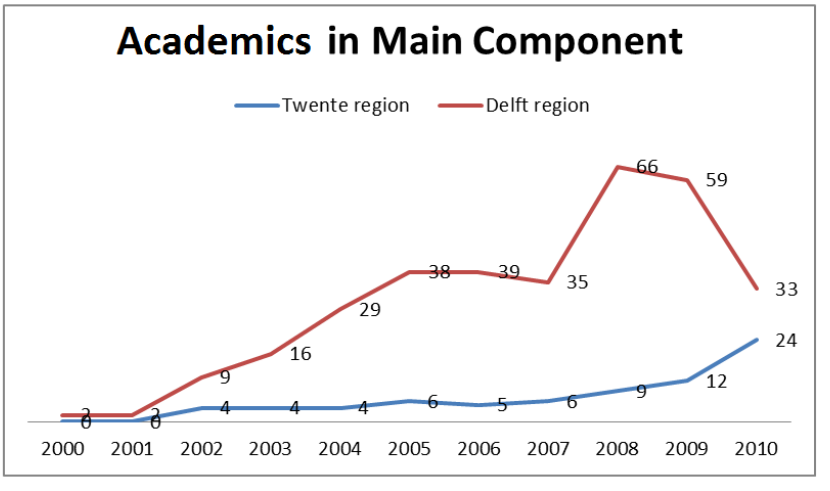


Figure 19, Number of academics in main component

An interesting observation from in last column in table 4 and in figure 19 is that the MC in Twente is so small that it sometimes exists only out of academics, and sometimes contains no academics at all. In the years 2002 and 2004, the number of academic inventors in the MC (4 academics) is equals the total inventors in the MC (also 4 inventors). This means the whole main component exists solely out of academics, who probably all worked on the same invention. Due to this relatively small main component size, we will not solely use the main component as a reference point. We will rather use all the data from a region. However, the fact that the main component is almost nonexistent in the Twente region is still an important observation.

4.4 ACADEMICS IN INVENTOR NETWORK

If university scientists are more embedded in a regional economy, this has a positive impact on the ability of a university to commercialize science (Casper, 2013). Due to this studies elaborate inventor resume check this thesis aims to contribute to this theory. Accurate analysis on the social networks could be performed, and descriptive statistics on this analysis can be found in Table 5. The first row (1) shows the number of academic inventors in the network. This is the amount of inventors that were employed by a university at the time they were involved in a patent application. The second row (2) shows the percentage of these academic inventors in the network. The third row (3) displays the amount of links between academics and inventors. For instance, if an academic was involved in a patent application with 3 industry inventors, this leads to 3 academic-industry links. If 2 academics were involved in a project with 2 other industry inventors, it would lead to 4 academic-industry links. The last and fourth row presents the percentage of the amount of links that can be called an academic-industry link. Due to the small main component size of the Twente network we have chosen to analyze statistics from the whole network.

Table 5, Statistics on academics in inventor networks

	Nr. Of academic inventors in network		% of academic inventors in network		Nr. of academic - industry links		% academic -industry links	
	Delft	**Twente**	**Delft**	**Twente**	**Delft**	**Twente**	**Delft**	**Twente**
2000	79	17	20%	37%	50	4	9%	8%
2001	84	17	22%	31%	59	6	11%	11%
2002	100	22	26%	39%	69	6	12%	13%
2003	116	26	24%	46%	90	4	13%	8%
2004	142	26	23%	48%	122	2	13%	4%
2005	168	36	25%	49%	128	10	11%	14%
2006	174	48	23%	53%	142	14	11%	16%
2007	189	50	22%	45%	170	17	11%	14%
2008	206	59	22%	44%	170	29	10%	14%
2009	194	60	20%	38%	164	37	9%	15%
2010	178	80	19%	42%	136	43	8%	13%

Firstly, we will take a look at the number of academic inventors in the network. Figure 22 shows a good representation of the data. There is a substantial growth in the amount of academic inventors in Delft from 2000 until 2008, then follows a slight decline in the upcoming years. Twente however, shows a more stable growth. The amount of academics almost doubles between 2000 and 2005 from 17 to 36 academics, and then doubles again in the upcoming years to 80 academic inventors. However, the amount of academic inventors in the Delft region is on average still a lot higher than in the Twente region.

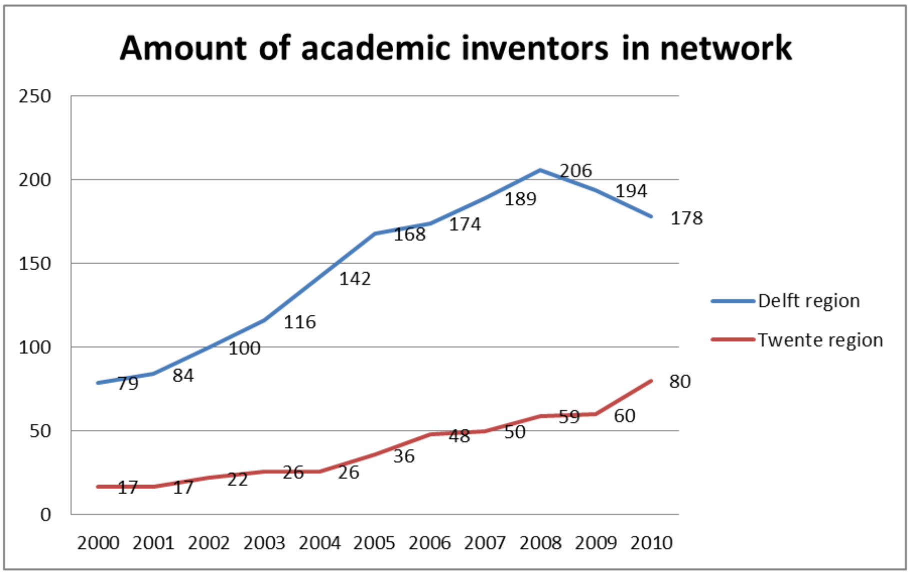


Figure 20, Academic inventors in network

Secondly, we will look at the amount of academic- industry links. This data is presented in the third row of table 5, and visualized in Figure 23. This data matches the data on the amount of academic inventors, with both regions showing a growth, and Delft a slight decline after 2008. Remarkable, however is the gap between the two regions. Relatively speaking, this gap is much bigger throughout the years than the gap seen in the amount of academic inventors.

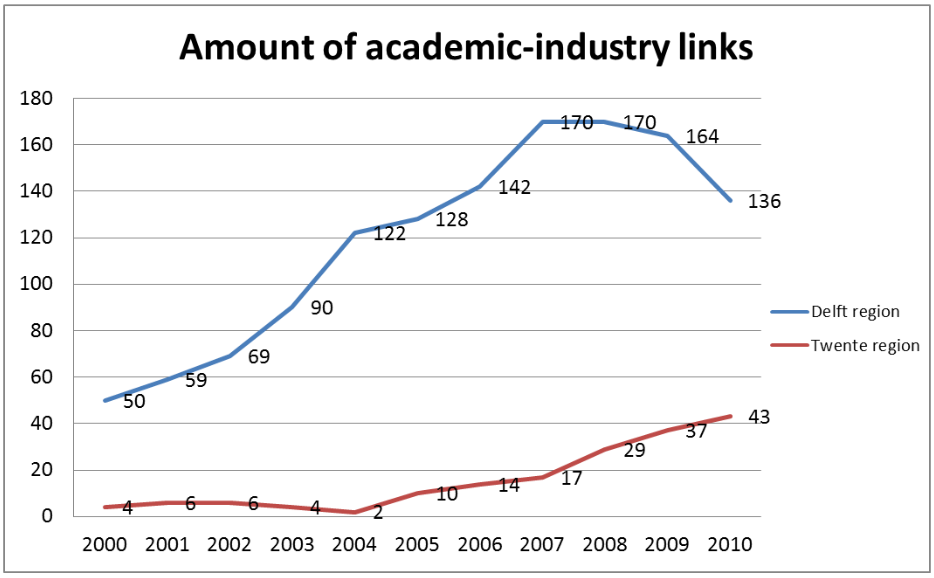
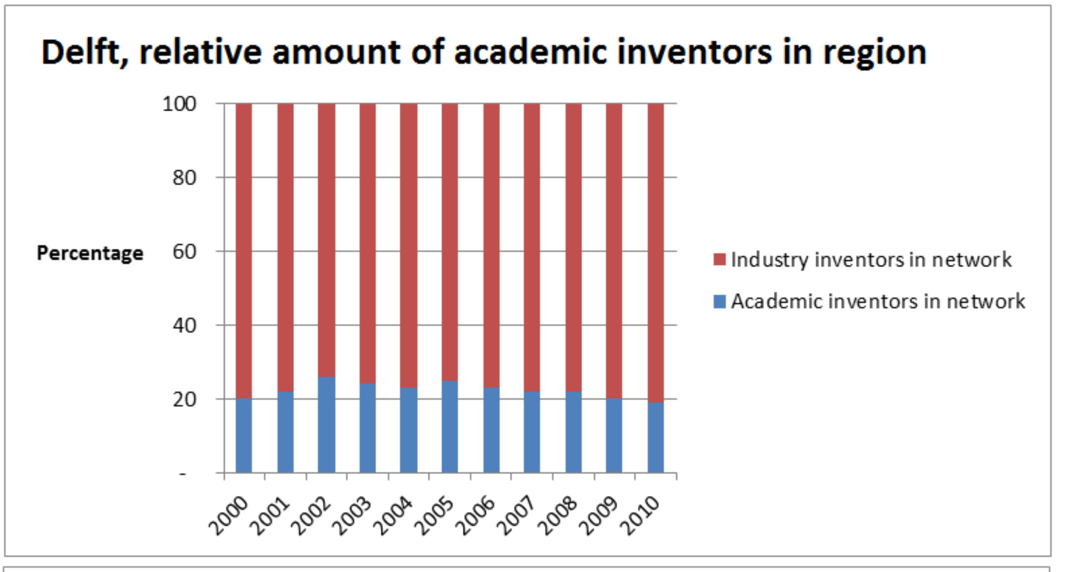


Figure 21, academic-industry links

In figure 24, the relative amounts of academic inventors are displayed per region. The Delft region shows an average of around 20% academic inventors in the network. Twente shows about double that amount, with an average of around 40% of academics.



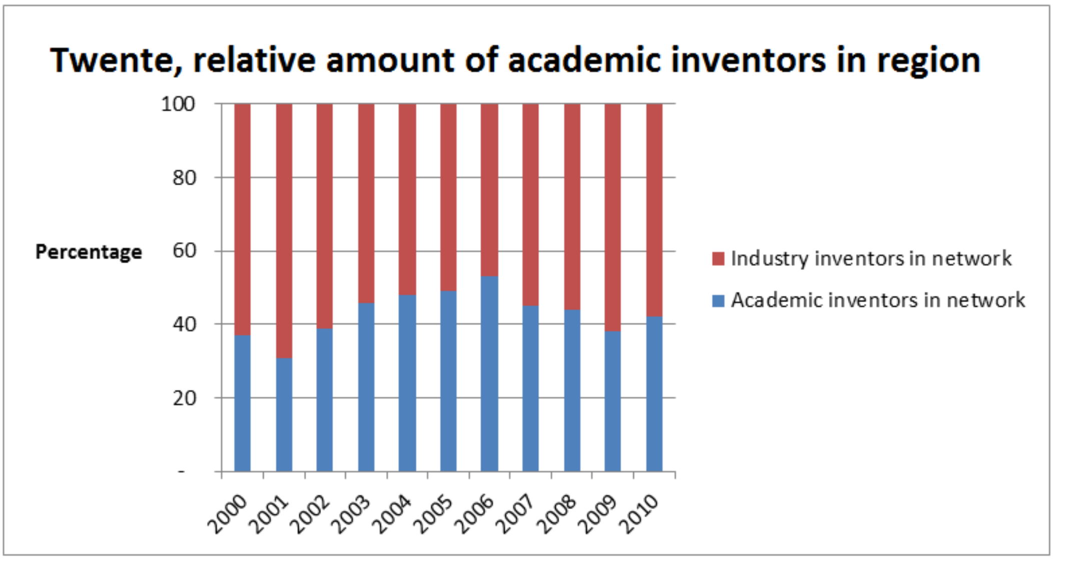


Figure 22, relative amount of academic inventors in regions

An interesting observation can be made when comparing the percentage of academic inventors and the percentage of academic-industry links. Even though the percentage of links that connect academics with industry is only slightly larger, the saturation of academic inventors in the network is much higher for the Twente region. The percentage of academic inventors in the network is about twice as high for Twente when it is compared to the Delft region.

5 DISCUSSION

This part of the thesis will discuss the outcomes of the results. Certain correlations and numbers will be discussed and we will look for explanations. In this part, also the results will be compared to results of earlier studies in the same research field. Then the differences and similarities will be clarified. The structure of this chapter is the same as in which the results were presented. However, the subchapters will build upon each other, providing new insights when the data is compared to the previously discussed topics. This way, we can also discuss correlations between commercialization data and network data.

5.1 COMMERCIALIZATION

Looking at the commercialization data, we can safely assume that TU Delft possesses a considerably bigger commercial output than UTwente. Relatively speaking, the TU Delft about twice the size as UTwente. The data on 3rd income stream activities is in line with this size difference. The TU Delft exceeds the UTwente by slightly more than twice the total amount of 3rd income stream revenue (840 / 409).

This would not prove the TU Delft to be more successful than UTwente; however the data on patent applications shows us a different story. On average, the TU Delft produces about 4 times more yearly patents than the UTwente. Earlier in this thesis it was confirmed that patent applications are an excellent measure of a universities commercialization output. Therefore we can confirm that, even though the TU Delft is a bigger university than UTwente, its commercial output is still much higher.

However, these findings also suggest TU Delft is still having difficulties with generating reasonable income through this IP. Four times more patents are applied for, and only double the amount of revenue is created through 3rd income stream activities. We can conclude from this data that patents are not yet efficiently utilized as a source of revenue by the university. An interview with TU Delft valorization center confirmed this suggestion. It was admitted that until 2016, patents are not profitable assets of the University. However, in the coming years, TU Delft aims to generate considerable revenue through their increasing patent portfolio.

Literature shows several reasons why it universities are having a hard time generating revenue through IP. Firms have trouble assessing the quality of an invention, this makes for a doubtful decision to invest in a universities patent. On the other hand, it is proven that researchers find it difficult to assess the commercial profitability and usefulness of their inventions. This problem is studied by Macho-stadler et al. (Macho-stadler, Pérez-castrillo, & Veugelers, 2007). These reasons are probably also why TU Delft is still struggling with commercializing their inventions and intellectual property.

5.2 NETWORK SIZE

The results on network size show a tremendous difference between the two regions. Even though both regions show growth, the Delft network grows to consist of 4 times more inventors in 2010. However, Twente's growth is relatively bigger, growing from 46 inventors to 192 (417% growth), in comparison to Delft's growth from 398 to 930 inventors (234%). Still, looking at the graphs in figure 16, it is highly unlikely that the Twente network will come close to the size of the Delft network in the coming years.

One of the reasons for the bigger sized network in Delft is the presence of the TNO (Dutch Organization for Applied Scientific Research) in the Delft region. This is a public organization that focuses on innovation and applied research. It consists out of approximately 2800 employees and it works to develop and apply knowledge. This makes it the largest research institute in the Netherlands. The organization grants licenses for patents, but also conducts contract research and it offers specialist consulting services.TNO is also known for setting up spin-offs to market innovations. The presence of TNO in the Delft region contributes to the size of the inventor network due to its extensive patenting policy. Many inventions are patented by TNO, but they are not the only reason why the network size is bigger in the Delft region. During the measured timeline, there were 1806 patents applied for in the Delft region. From these 1806, 1296 patents were applied for by the TNO. This means that about 70% of all the patents in the Delft analysis are from TNO.

Another company in the Delft region that's highly influential on increasing the network size is Mapper Litography. This company is an interesting case study for us, because it originates from the TU Delft. The company is founded in 2000, by Peter Kruit, a professor from Delft University. The company develops maskless lithography infrastructure for the semiconductor industry. As of now, the company employs 250 people and has a manufacturing facility in Moscow, Russia. This company is the perfect example of how an inventor network not only influences the universities commercial performance, but this also works the other way around.

The Twente region also has some highly innovative enterprises. One of them is Novay, this company was a Dutch research institute in the field of Information Technology (IT). It was formerly known as the Telematica Institute. In 2009 the company changed its name to Novay and at employed about 100 people. They focused on solutions for businesses and society, in a wide range of subject areas like IT, but also organizational science, sociology and psychology. Even thought this company was very impactful on its regions innovation system, it accounted for only 3 patents during the measured period. Unfortunately the company dissolved in 2014.

Another influential company in the Twente region is Micronit, accountable for 12 patent applications during the measured period. This company designs, develops and manufactures custom made microfluidic components based on micro and nanotechnology. The company houses about 70 employees and was founded in 1999. It is still growing since.

Even though Twente has some very influential and innovative companies in its region, in the patent analysis, their size is not very big when compared to the sheer number of patents that the TNO produces. If we place the findings on network size in line with the findings about the commercial performance, we can see a clear correlation between the two.

(1) As both networks grow in each region, the universities in the region also show an increased commercial performance. However, this network growth is not consistent to the growth of the commercial output. The years in which the network grows the most, are not always the years in which the universities commercialization grows as well. It could be suggested that there is a delayed reaction, when the network increases; it takes a while before the university fully utilizes the network in growing its commercial activities.
(2) In terms of the amount of inventors, the delft network grows to be four times the size of the Twente network, and the commercial output from TU Delft has also grown to be four times the size of UTwente.

From this we can safely conclude that the inventor network size positively influences the universities commercial performance. These findings support our hypothesis.

5.3 NETWORK MAIN COMPONENT

The Twente region has a network main component of only 25 inventors. This means that there is hardly any collaboration between the inventors in the region. This region is also lacking influential figures who have a big network of inventors around them which whom they share knowledge and expertise. Delft on the other hand scores better on the network main component size. Delft has 55 inventors in the MC in 2000, and grows to 469 inventors in 2010. The size difference between the regions network main components is enormous. In 2000 the Delft MC was 9 times the size of the Twente MC. In 2010, the Delft MC grew to be almost 19 times larger than that of the Twente region.

However, the fact that only 7% of the Delft network main components exists out of academics; it is likely that this main component is highly influenced by the presence of TNO in the area. TNO produces enormous amounts of patents, and because of the inventors being colleagues, it is more likely that there are more connections.

Twente on the other hand, has a much higher relative amount of academics in the network main component. The MC in this region sometimes exists solely out of academics, and in 2010, 24 of 25 inventors in the main component are academics. In this we can see that the region is lacking big innovative firms like the ones that Delft has. Nonetheless, this data proves that with a bigger sized network main component is beneficial for the commercial output of a University in the region.

5.4 ACADEMICS IN INVENTOR NETWORK

When looking at the total amount of academic inventors in the regions in 2010, Delft has about double the amount of academics than Twente. Interestingly enough, the percentage of inventors who was an academic at the time of the patent application (the relative amount) is about twice the size for the Twente region. As you can see in table 5, the percentage of academic inventors in the Twente network scores an average of 40%, even though this is only 20% for the Delft region.

One reason for this difference could be that, apart from the university, Delft has more innovative companies that depend on patent applications in the region... The presence of TNO and other big firms could lead to the fact that there are many “industry” patent applications in the region, resulting in relatively less academic inventors in the statistical analysis. One way or another, it proves that both regional economies have quite a large amount of academics in the inventor networks. And in both regions, the universities could be quite involved in the inventor network.

The percentage of academic industry links however, is only slightly larger for the Twente region. Over the measured period, Delft scores an average of 11%, and Twente an average of 12%. So how can it be, that the percentage of inventors is twice the size for Twente, but the percentage of links between academics and industry inventors is the same?

The fact that the percentage of academic-industry links is almost equal in both regions could indicate that they are both collaborating within their industry networks on the same level. They both utilize the size of the network in the same manner, however TU Delft gets more opportunities due to the increased size of the network surrounding the university. The relatively smaller size of the Twente network then also results in the bigger relative percentage of academic inventors. For example, in the year 2006 this region contained more academic inventors than industry inventors (53% academics). This implies little innovative capacity from the regions industry, as there are more academic inventors than inventors from industry.

It could also mean that Delft is collaborating with its environment in a different way. Delft region has relatively less academics in the network, but the same amount of links. This could mean that the teams in which patents are applied for consist of different and more varied structures. This finding could suggest that there are more teams with both academics and industry professionals, and less teams with only industry professionals or only academics. Either way, it suggests a stronger social network in the Delft region.

From these findings, we can argue that the size of the network and the size of the network main component are more beneficial for the universities commercial success, than the amount of academics in the network. However, the way the university collaborates with this industry is still important. From two universities showing the same level of collaboration with their industry, the one with the bigger network will benefit more from this.

6 CONCLUSION

The conclusion aims to answer the following research question:

"Do stronger social ties in a regional innovator network positively influence the commercial output of that regions University?"

Three measures are used to determine how strong the social ties in the innovator network are. These are (1) the size of the network, (2) the size of the network main component, and (3) the amount of academics there are in the network. This allowed us to arrive to three hypotheses that prove beneficial in correctly answering the research question.

Hypothesis 1: "The size of the regional inventor network positively influences the universities commercial success"

Our results support this hypothesis, as both Delft and Twente networks grow bigger, the universities in both the regions also experienced an increased growth in commercialization output. Furthermore, the Delft network grew faster than the Twente network, and the University in Delft also had a higher commercial performance than the University of Twente.

Hypothesis 2: "The size of the regional network main component positively influences the universities commercial success"

We have also found evidence that supports this prediction. both network main components grew in size, as well as the commercial output of the universities. As Delft's main component grew faster than that of the Twente region, its commercial output also grew more in size.

Hypothesis 3: "more collaboration between academic inventors and industry inventors leads to increased commercial performance of the university in a region"

Strictly speaking, we have found proof to support this prediction, as the raw number of academic inventors in the Delft region is double as high as its measured counterpart, and so is the commercial performance of the University. However, relatively speaking, The Twente region is more saturated with academic inventors as the academic inventor's average a 40% of the total inventors, in comparison to the 20% of the Delft region.

We have also seen that the percentage of links between academic inventors and industry inventors in both regions is somewhat the same. It could be argued that both universities participate in commercial activities with their regional economies in the same manner, but Delft University has higher commercial benefits due to a more extensive surrounding inventor network. This allows for more opportunities in knowledge sharing, contractual research and investments in Intellectual Property.

It could also be argued that the Delft network has stronger social bonds between Academics and Industry. Relatively less academics and the same relative amount of academic-industry links could suggest more diverse project teams and a stronger mix of academics and industry professionals.

7 LIMITATIONS & FUTURE RESEARCH

This research slightly deviates from the previously performed research on inventor networks. Two main concerns could impact the results of this thesis. The first one is the fact that there was a slightly different patent selection method used. Patents were selected based on the address of the patent's applicant. The TNO, registered about one third of all its patents in Delft. This resulted in the fact that 70% of the selected patents from Delft are from TNO (1296/1806). Through our research method, all these registered patents are involved in the analysis, together with all the inventors who participated in their creation. This could include inventors from different parts of the country, who should otherwise not be part of the regional network in Delft. Some patents could be selected for analysis, with none of the inventors inhabiting the chosen region. A better way to select the patents for the analysis is to use the inventor addresses, rather than the applicant address. A common way that has been used in previous research is to first make a selection of all the inventors in a region, and then select all the patents that they cooperated on in a certain year. Then the connections are formed with all the inventors who cooperated on that patent. This way, you select all the patents with at least one inventor in the region, instead all of the patents which are owned by an organization in a region. This method is slightly more accurate, but still includes inventors that are not from the chosen region. Sadly, the European Patent database that was used for this research did not include addresses for inventor data, forcing us to deviate from standard research methods in inventor networks.

The second limitation that arose from this research is the fact that the network main component in Twente was too small to accurately compare to Delft. In previous research, data was solely drawn from the network main component. The main component from Delft was big enough, but Twente was too small to generate any data on the academic inventors in the region. On the other hand, the fact that it is so small is an interesting observation in itself and tells us a lot about the low connectivity between inventors in the region.

A third limitation arose in the phase where the academic inventors were identified in the network. Inventor's names were used to find them on LinkedIn, search engines and in publications. However, we were unable to track about 5 percent of inventors that were checked. For these inventors there were no records found on the internet, and by default they are marked as an industry inventor. This is a small limitation, as it only concerns 5% of the inventors, and the chance that an academic inventor has no publications on the internet is miniscule.

Future research on the impact of regional economies on academic commercialization could provide us with extra insight and confirmation of the results in this thesis. The same research method could be used, with some slight changes to overcome the limitations that this research posed. At first, it could be interesting to find a European database that allows for the inventor addresses to be used. We were not able to find a way as of yet, but in the future there could be more different databases to be of use for this research. Some initiatives are already being undertaken to make the current databases more accessible to use for research purposes (Armbruster, Bikfalvi, Kinkel, & Lay, 2008; Lissoni, 2013). It could be that some harmonization projects result in a better database with more elaborate inventor data.

For future research it could also be interesting to look at different regions in Europe, or focus on a specific industry. Focusing on bigger regions could provide more interesting insights in the network main component, but the inventor background analysis will be more time consuming. Inventor backgrounds are checked manually, and for a bigger region this could take up too much time. In the first case, for this thesis the Delft and Eindhoven regions were to be compared. However, after seeing the amount of patents and inventors in the Eindhoven region, we decided to pick a smaller region (Twente) due to time constraints in the inventor background analysis. A way to deal with this is to determine a certain industry or technological field. For instance, by scoping only on biomedical patents or nanotechnology patents you can reduce the inventor list enormously, making it possible to perform the inventor background check.

8 ABBREVIATIONS

EIS	European Innovation Scoreboard
EPO	European Patent Office
IPR	Intellectual Property Rights
IS	Innovation System
MC	Main Component
NMC	Network Main Component
NSI	National Systems of Innovation
OECD	Organization for Economic Cooperation and Development
RIS	Regional Innovation System
TIS	Technological Innovation System
TTO	Technology Transfer Office

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10 APPENDIX

APPENDIX 1: PATSTAT QUERY DELFT 2010 EXAMPLE

```
SELECT main.person_id, sub.person_id, meen.doc_std_name, subb.doc_std_name
FROM tls207_pers_appln AS main
JOIN tls207_pers_appln AS sub ON sub.appln_id = main.appln_id
JOIN tls206_person AS meen ON meen.person_id = main.person_id
JOIN tls206_person AS subb ON subb.person_id = sub.person_id


WHERE main.person_id IN
(
SELECT tls207_pers_appln.person_id
		FROM tls207_pers_appln
		JOIN tls206_person
		 ON tls206_person.person_id = tls207_pers_appln.person_id
		WHERE appln_id in
(
				SELECT DISTINCT tls207_pers_appln.appln_id
				FROM tls207_pers_appln JOIN tls206_person
				ON tls207_pers_appln.person_id = tls206_person.person_id
				JOIN tls201_appln ON tls201_appln.appln_id = tls207_pers_appln.appln_id
				WHERE tls207_pers_appln.applt_seq_nr  = 1
				AND  tls206_person.person_address LIKE '%Delft%'
				 AND tls201_appln.appln_filing_year > 2004
				AND tls201_appln.appln_filing_year < 2011
		)
		AND tls207_pers_appln.invt_seq_nr >= 1
		AND tls206_person.person_ctry_code = 'NL'
)
AND sub.person_id IN
(
SELECT tls207_pers_appln.person_id
		FROM tls207_pers_appln
   JOIN tls206_person
   ON tls206_person.person_id = tls207_pers_appln.person_id
		WHERE appln_id in
(
				SELECT DISTINCT tls207_pers_appln.appln_id
				FROM tls207_pers_appln JOIN tls206_person
				ON tls207_pers_appln.person_id = tls206_person.person_id
				JOIN tls201_appln ON tls201_appln.appln_id = tls207_pers_appln.appln_id
				WHERE tls207_pers_appln.applt_seq_nr  = 1
				AND  tls206_person.person_address LIKE '%Delft%'
				 AND tls201_appln.appln_filing_year > 2004
				AND tls201_appln.appln_filing_year < 2011
		)
		AND tls207_pers_appln.invt_seq_nr >= 1
		AND tls206_person.person_ctry_code = 'NL'
)
AND main.person_id != sub.person_id
AND main.person_id > sub.person_id
GROUP BY main.person_id, sub.person_id, meen.doc_std_name, subb.doc_std_name

ORDER BY main.person_id ASC
```