This thesis tests the effects of specialization and relatedness at sector level on entrepreneurship in Eindhoven. The results show that both specialized sectors and their related sectors show an increase in the relative amount of startups as compared to their non-specialized counterparts in other cities in the area, even after accounting for regional differences. The amount of jobs in startups remains relatively constant.

The Effect of Specialization and Relatedness on Entrepreneurship in Eindhoven

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Abstract

Both entrepreneurship and the relative advantages of specialization and diversity have been at the centre of research and discussion in recent years. It has been established that there are large differences in entrepreneurship between regions, often exceeding national differences (Andersson & Koster, 2011). This is due to factors such as population characteristics, social and financial institutions, and a role-model effect.

The aim of this thesis is to establish whether there are differences not only at the regional level, but also at the sector level due to specialization and/or relatedness. This leads to the following research question: *What are the effects of specialization at sector level on entrepreneurship in that sector and sectors with different levels of relatedness?* Specialization here means that a sector is comparatively large in a city as compared to the relative size of its counterparts in other cities. Relatedness means that the sector is not itself specialized but is closely related to a specialized sector.

To answer the research question data from the LISA-statistics have been used. The data is aggregated to sector level rather than individual startups in blocks of three years. This aggregated data is subsequently used to establish which sectors are specialized or related and which are not, and to calculate the startup rates in the sectors. Afterwards the startup rates are compared between the three groups which consist of specialized, related, and non-related sectors for the six cities in the southern part of the Netherlands, and for the city of Eindhoven specifically. The results show that in both cases the specialized sectors show a comparatively higher startup-rate than non-specialized sectors. Related sectors also show a higher startup-rate than their non-related counterparts but the effect tends to be smaller than that of specialized sectors.

The results indicate that specialization may have a positive effect on entrepreneurship in the sector itself as well as on sectors that are considered related. However, how specialization and relatedness can be defined is debatable and the advantages of diversity have not been explored. It is thus very well possible that specialization may have a positive effect on the specific sector, but has a detrimental effect on the general startup-rate in the region. Therefore, further research is required to fully explore the relationship between specialization, relatedness, diversity and entrepreneurship.

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1. Introduction

The aim of this thesis is to explore the effects of a high level of specialization at industry level on entrepreneurship, both on itself and related sectors. Scientifically, this thesis can thus be related to two broad fields of research and discussion within economic geography. These fields of course are entrepreneurship, as seen from an evolutionary economic perspective, and the relative advantages of specialization and diversity. For this research the city of Eindhoven will be used as a case study as there is a very strong focus both from the regional as well as the central government on one particular sector; the high-tech systems and materials sector. In section 1.1 will be discussed why entrepreneurship is an interesting topic of research in general. Section 1.2 will discuss why influences on entrepreneurship may very well be, to some extent, be sector specific. Section 1.3 will explain the use of Eindhoven as an interesting case, followed by the formulation of the research questions in section 1.4.

1.1 Increasing attention for entrepreneurship

Entrepreneurship has seen an increasing level of attention over the last few decades, both in popular and scientific media. Entrepreneurship is the combining of various resources, including land, labour, capital and natural resources in a business to produce profit or income, with the most obvious example being a new start-up company or greenfield investment (Schumpeter, 2000). Rob Wolthuis, secretary of MKB Nederland, an organization which aims at improving the entrepreneurial environment of the Netherlands, especially for small and middle-sized enterprises, states as translated by this author: “There is only one driving force behind (economic) welfare and that force is entrepreneurship.” (Wolthuis, sd).

The vision of Wolthuis is neither singular nor unique. Throughout Europe there has been an increasing amount of events with an implicit or explicit focus on entrepreneurship, often with a focus on an industry that is well-developed in the region. One needs only to look at one of several online calendars listing start-up events, such as alphagamma.eu, to see startup events focused on financial and banking technology in London (Finovate), on legal and privacy and data protection in Brussels (CPDP), or on the entertainment industry in Cannes (MPTV and Midem). In the Netherlands there have been several events around Startup Fest Europe with several events around specific topics such as Food and agriculture, FinTech, High Tech, Water Tech, Energy, Health Tech, Hard Science, Web Tech, Mobile Tech, and Smart Cities in several cities (Startup Fest Europe, sd)

1.2 Specialization and path dependency

The sources and relative advantages of either specialization or diversity within an agglomeration economy have already been explored by authors such as Duranton and Puga (2004), Vernon (1966), Porter (1990), Chinitz (1961, 1964), and Jacobs (1960) whom all ascribe different advantages due to different configurations of the regional economy. A textbook overview of their different points of view can be found in McCann (2013) and in Glaeser (2010). Most of these studies deal with economic development of an area as a whole, or of a particular sector. Internal to the discussion is the question which of the two offers the most benefits with regards to innovation. Proponents of specialization argue that specialized areas offer advantages through local spillovers of knowledge and a large local labour pool as well as competition. Proponents of diversity argue that innovation is largely due to cross-industry knowledge spillovers, in which different industries learn from each other to form new ideas.

Martin & Sunley (2006) define path-dependent system or process *"whose outcome evolves as a consequence of the process's or system's own history".* The broad implications of path-dependency are that historic characteristics and chance events in the region's history are likely to affect future characteristics and events. Research from an evolutionary economic perspective into path dependency and entrepreneurship has at the same time provided evidence that regional variation in entrepreneurship is both persistent and significant, often exceeding national differences (Verheul, et al., 2001; Wagner & Sternberg, 2002; Fritsch & Mueller, 2007; Bosma & Schutjens, 2011; Andersson & Koster, 2011). Entrepreneurship here has a certain stickiness to it. Entrepreneurship in one period can thus largely be explained by previous entrepreneurship. What we do not know yet is how this relates to specialization. As explained, theories on specialization all detail perceived benefits on innovation and by extent entrepreneurship. It is thus likely that a regional focus on a well-established sector, for instance through start-up activities such as mentioned in sector as well as internal mechanisms due to localization benefits, may have higher levels of entrepreneurship as compared to non-specialized counterparts. By combining the theoretical work on the relative advantages and effects of specialization and diversity on one side, and the evolutionary economic notion of path dependency on the other it can easily be imagined that path dependency and local differences in entrepreneurship may not only be a regional phenomenon, but also a regional industrial phenomenon.

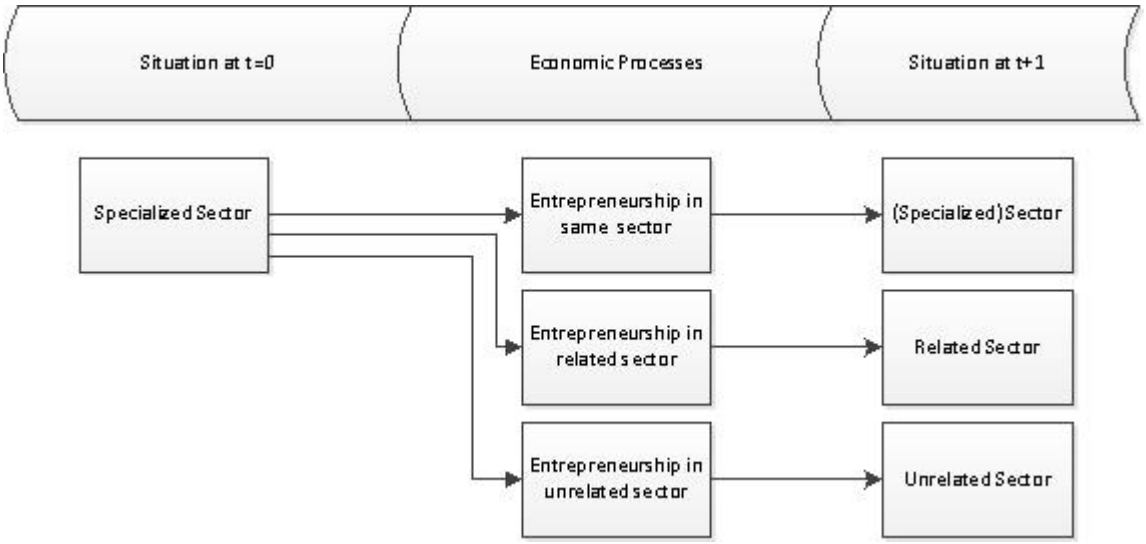


Figure 1 –Conceptual model.

The conceptual model in figure1 visualises the central problem of this thesis. The focus of this research is if and what kind of effect specialization in a sector in a previous time period has on entrepreneurship in a later time period, both on itself and related sectors, as compared to unrelated sectors. To examine the effect of specialization it is necessary to first determine sectors that can be considered specialized. Furthermore, the specialized sectors will need to be compared with non-specialized counterparts, as comparing entrepreneurship across non-similar sectors of industries would create a bias. This means that a sector which has been defined as specialized will need be compared to the same sector in at least one other city. There is also a need to create a framework by which to determine which sectors can be considered related to a specialized sector to further examine the effect of specialization in one sector on other sectors. Last, it is imperative that there is enough data over an extended period of time.

1.3 Eindhoven as a case

The city of Eindhoven itself acknowledges the position of its specialized sector and describes how previous specialization influences contemporary results. Eindhoven thus provides a very good case as a city in which there is specialization and there already is a perceived effect of past specialization on present processes that fit the path-dependent relationship between specialization and entrepreneurship as described in the previous sections. The city is at the centre of the so-called Brainport, an area within the Netherlands with a high level of specialization and a strong focus on technology. Besides general start-up promotors and accelerators, such as Startup Eindhoven that offer guidance to starting entrepreneurs, many other start-up promotors and accelerators choose to specialize on the perceived strong

points of the region through a specialization in the high-tech systems and materials sector. Examples are Brainport (www.brainport.nl), NEXTOEM (http://www.nextoem.com/) and Eindhoven Startups (http://www.eindhovenstartups.com/) all of whom mention Brainport in their subtitles and explicitly mention the technology sector. It should at this point be noted that the brainport is commonly used in two ways. First it is the general area around Eindhoven, and secondly it is the union of 21 communities, enterprises and knowledge institutions unified in the brainport association as mentioned before (www.brainport.nl) and seen below. In this thesis the focus will be on the city of Eindhoven rather than on the entire area, as city level data is easier to compare than and data on what constitutes the exact region is not readily available for the regions with which Eindhoven is compared nor is it clear why certain parts are in- or excluded in the brainport area.

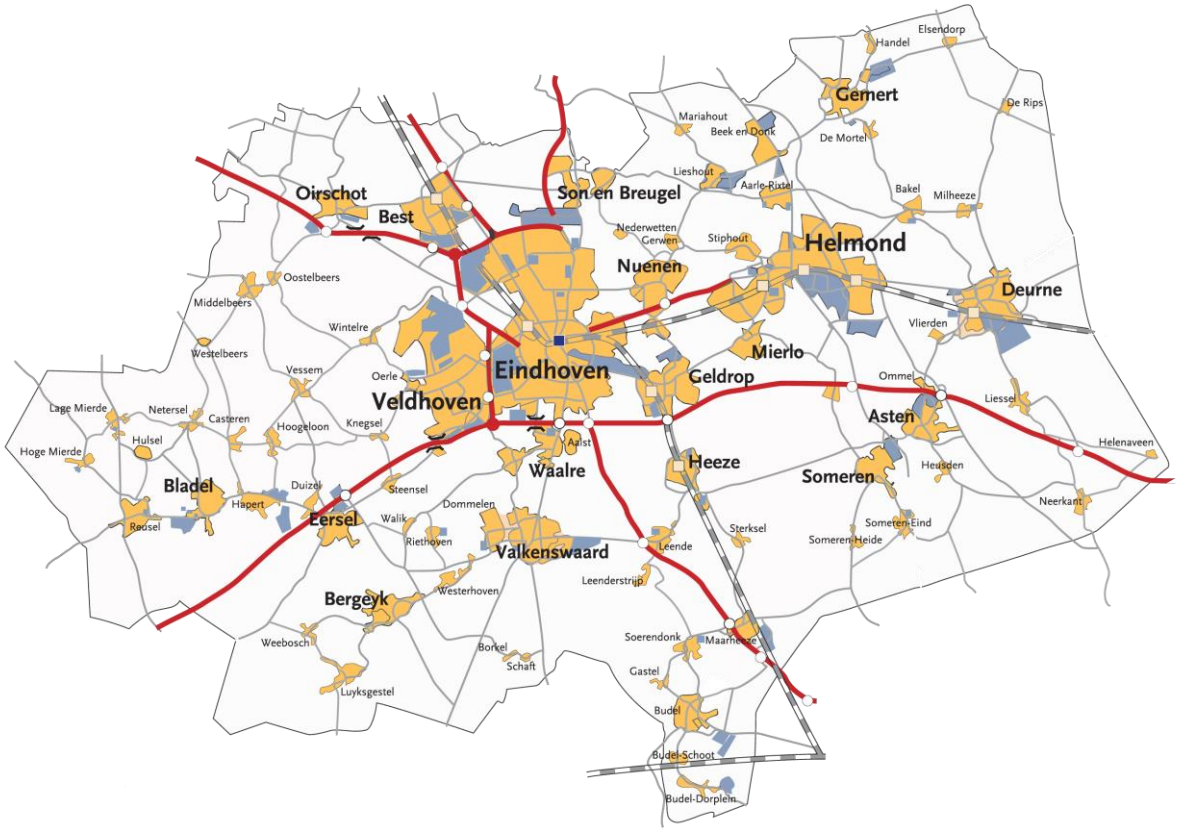


Figure 2 – Eindhoven and the brainport area.

On a national level high-tech systems and materials is one of the ten sectors that are perceived as exceptionally well developed in the country and therefore lot of policy and investments are made to keep up high standards and improve the efficiency and competitiveness of the sector. Central to this policy are the Topconsortia for Knowledge and Innovation, or TKI. These are independent organisations aimed at improving the cooperation between different enterprises within the sector, for instance by cooperating and joint investments in research projects

(http://www.hollandhightech.nl/nationaal/innovatie/nationale-programma-s/tki-regeling). For the high-tech systems and materials sector this TKI is called Holland High Tech, an organization that lists a total of eight partners. Three of these partners are based in the city of Eindhoven and one is based in the direct vicinity of the city, informally marking Eindhoven as the centre of high-tech systems and materials in the Netherlands.

According to the Brainport association the high level of specialization has some impressive effects on the area, all of which are related to economics or the continuity and consistency of the level of specialization. The economy grew 3% in 2015, which is 1.5 times the national average, 42% of the national patents originate in the brainport area, 50% of the youths choose to specialize in technology in secondary school, and the area has 4480 new beta students in higher education (www.brainport.nl). This should sound very similar to the arguments of the previous paragraphs on path dependency. All of this indicates that there might be a strong effect of specialization on regional economic development. However, it remains unclear which part of this is due to the high-tech systems and materials sector, or other sectors that can be considered specialized, and what part to other sectors either related or unrelated to the high-tech systems and materials and similar sectors. Similarly, the data does not detail if the economic growth is related to entrepreneurship or whether all economic growth is created within existing firms.

1.4 Research

First, to look at the effects of specialization on entrepreneurship, using Eindhoven as a case study, a comparison will need to be drawn between the general levels of entrepreneurship in the case, Eindhoven, and similar cities for which five other cities in the area have been chosen. These cities are Tilburg, Nijmegen, Arnhem, Den Bosch, and Breda. These cities have been chosen because they share a general area with Eindhoven in the southern part of the Netherlands and are likely to be similarly affected by disturbances over time, such as economic fluctuations at a macro level. To make sure the cities are comparable, the general levels of entrepreneurship will be compared to establish what levels of entrepreneurship can be expected in each city and sector. Secondly, we will look at the existing levels of entrepreneurship in Eindhoven, and how the levels of entrepreneurship relate across sectors. Using these two measurements it will become clear whether the benefits of specialization are internal to only one sector or will have effects across sectors to some degree.

The research questions can be formulated as such:

M1: *"What are the effects of specialization at sector level on entrepreneurship in that sector and sectors with different levels of relatedness?"*

To answer the main question, using Eindhoven as a case study, the following two questions will need to be answered. The first question is necessary as to say anything about entrepreneurship in the city of Eindhoven, it becomes necessary to compare the levels of entrepreneurship with other cities. If there are regional differences in entrepreneurism this of course needs to be corrected for. The first sub question therefore is:

S1: *"How has entrepreneurship in Eindhoven developed compared to other cities in the Netherlands?"*

After exploring regional differences in entrepreneurship, the different sectors will need to be categorized in one of three groups which can then be compared. These groups are specialised sectors, sectors related to specialised sectors, and non-specialised sectors. By doing so, the relative startup-rates for each sector can be compared to the same average which includes the control cities to establish if there are differences in startup-rates between the groups, and whether startups in specialized or related sectors differ in the amount of jobs per enterprise.

S2: *"How has entrepreneurship in Eindhoven developed in non-specialised sectors, specialised sectors, and sectors related to specialised sectors in comparison to each other?*

By answering these questions this thesis will explore the effects of specialization on entrepreneurship, while accounting for regional differences. The aim of this thesis is then to expand upon the existing literature dealing with entrepreneurship, the relative advantages and disadvantages of both specialization and diversity, and path dependency.

1.5 Overview

In chapter 2 the concepts used in this thesis will be explained and a theoretical framework will be built. Section 2.1 will foremost with what constitutes entrepreneurship, and in what ways entrepreneurship and specialization may lead to more entrepreneurship and specialization based on previous studies regarding entrepreneurship and path dependency. Section 2.2 will deal specifically with literature on specialization and diversity, and how this may influence entrepreneurship. Chapter 3 follows on chapter 2 and details how the study is performed based on the framework provided by chapter 2. Section 3.1 expands upon the sub questions and the testable hypotheses. Section 3.2 discusses the different components and how they related to the research questions. Section 3.3 consists of the data analysis for the different sub questions and hypotheses. Finally, chapter 4 offers conclusions based on the data, and chapter 5 discusses the data, the results, and the limitations.

2. Theoretical Framework

2.1 Entrepreneurship

2.1.1 Defining entrepreneurship

Entrepreneurship can broadly be defined as the process of designing and launching of a new business in which the entrepreneur offers a product, process or service for sale or hire in order to make a profit (Schumpeter, 2000). The most notable form of entrepreneurship is a start-up. While several studies, including Anderson and Koster (2011), do point out that there are rather big differences within the group start-ups, many other notable studies such as Romanelli (1989), Agarwal and Gort (2002), and Fritsch and Mueller (2007) lack a proper definition of what constitutes a startup and do not differentiate between types of startups. Due to a lack of differentiation in the available data this thesis will similarly not differentiate between different types of startups, as they will be defined by their first appearance in the regional data set. However, it is worthwhile to keep in mind that in the same locality the circumstances may be very different for a greenfield startup then for spin-off or spin-out enterprises. The latter of these can be defined as an enterprise in which the founder uses knowledge and resources acquired by working for another enterprise or institution, to create a profitable process, product or service (Smilor, et al., 1990). Not only do these type of enterprises have access to additional knowledge, they may also be to some extent funded or owned by a former direct employer, or be linked to a former research institution such as a university which may alter its performance (Lockett, et al., 2015). Internal differences may be very relevant to the life and death of an individual startup, this will however not be discussed as it is beyond the scope of this thesis. For an overview see Garnsey et al. (2006), who provide an overview of several studies with regards to internal factors that may influence start-up survivability and growth, including factors such as founders skills and relevant experience and education, and Agarwal and Gort (2002) who focus on the effect of initial endowments and the acquisition of knowledge of both the product and market as well as the enterprise.

Entrepreneurship has two major functions within the economy. The first function of entrepreneurship is the ability to absorb economic shocks. Marschak and Nelson (1962), Audretsch and Zoltan (1994), and more recently Fritsch and Mueller (2007) and Andersson and Koster (2011) all argue that the most visible function of entrepreneurship is the apparent ability to absorb economic fluctuations. For instance, in a situation where incumbent enterprises face an employment reduction, there will be an increase in startup activity to compensate for the reduced employment chance. The second function is linked to the work of Schumpeter (1950). In his work Schumpeter described a life cycle in which a nascent enterprise was the result of a novel, often innovative, combination of resources in order to produce a product or service. At the same time, enterprises at the other end of the product life cycle would lose their viability and face bankruptcy, thus freeing their resources for market use and enabling new entrepreneurs to combine resources. Through this resources are continually used close to an economic optimum for as soon as an enterprise does not use resources adequately, it will be replaced. This type of reasoning also means that there is no fixed stock of entrepreneurial opportunities, as the opportunities are created by supply, demand and available resources. In recent studies on entrepreneurship this idea has been explored further with authors stating that the creation of new enterprises would lead to new entrepreneurial opportunities due to the fact that supply and demand of resources and the possibilities for the allocation of these

resources change with the existing stock of enterprises, as can be seen in figure 3 (Holocombe, 2003; Audretsch & Keilbach, 2004; Fritsch & Mueller; 2007; Andersson & Koster, 2011).

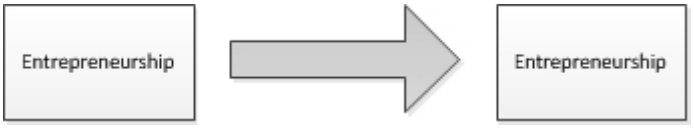


Figure 3 – The existence of entrepreneurial opportunities is dependent on the existence and use of entrepreneurial opportunities.

2.1.2 Path dependency and persistence in entrepreneurship

Entrepreneurship, though of course existing everywhere, is very embedded in the host locality. As stated in the introduction, variation in entrepreneurship in different regions often exceeds national differences (Verheul, et al., 2001; Wagner & Sternberg, 2002; Fritsch & Mueller, 2007; Bosma & Schutjens, 2011; Andersson & Koster, 2011). Andersson and Koster (2011) find that there are two mechanisms at work with which persistence can be explained. The first mechanisms consists of regional characteristics that are slow to change, and as such characteristics are persistent so too are their effects on regional entrepreneurship. Examples are the local infrastructure (Johansson, et al., 1996) and characteriscics of the local economy and population such as level of education, innovation activity, market-size, industry structure and agglomeration economies (Verheul, et al., 2001). The second mechanisms consists of regional path dependency in entrepreneurship, in which current levels of entrepreneurship are a response to previous levels of entrepreneurship. One reason for this is that a large population of small and young enterprises can positively influence the amount of future entrepreneurs (Wagner, 2004; Fritsch & Mueller, 2007). A reason for this is postulated by Fritsch and Mueller (2007) in that it is more likely in a small enterprise that employees come into direct contact with the business' founder who can act as a role model. This can be related to the previously made opportunities and resource allocation argument. In a locality with a large group of small and young enterprises it is likely that supply, demand, and available resources are continually changing thus creating opportunities for possible entrepreneurs. The recognition and grasping of these opportunities by potential entrepreneurs and the personal preferences of these potential entrepreneurs are thus possibly influenced by the entrepreneurial environment of the locality in which the potential entrepreneur finds himself (Verheul et al., 2001; Andersson & Koster, 2011). Institutions play a significant role in path dependency according to Petersen and Rajan (2002), Kenney and Patton (2005), Martin and Sunley (2006) and Guiso et al. (2004). Martin and Sunley (2006) explain that a stable institutional context can have a significant impact on startup activity. More specific, Petersen and Rajan (2002),Kenney and Patton (2005), Guiso et al. (2004), find that the local development of law and financing services have an important relation with startup activity. According to Petersen and Rajan (2002) and Guiso et al. (2007) especially young and smaller firms have a great dependency on financial services as they are less likely to have or to be able to create considerable reserves themselves. Di Gregorio and Shane (2003) similarly find that a proper set of supporting institutions by universities may affect startup activity in a similar fashion. Following the main argument of path-dependency, successful regional entrepreneurship can lead to better institutions, which in turn may lead to a better entrepreneurial environment sparking a cycle of economic and entrepreneurial growth. This has been visualized in figure4.

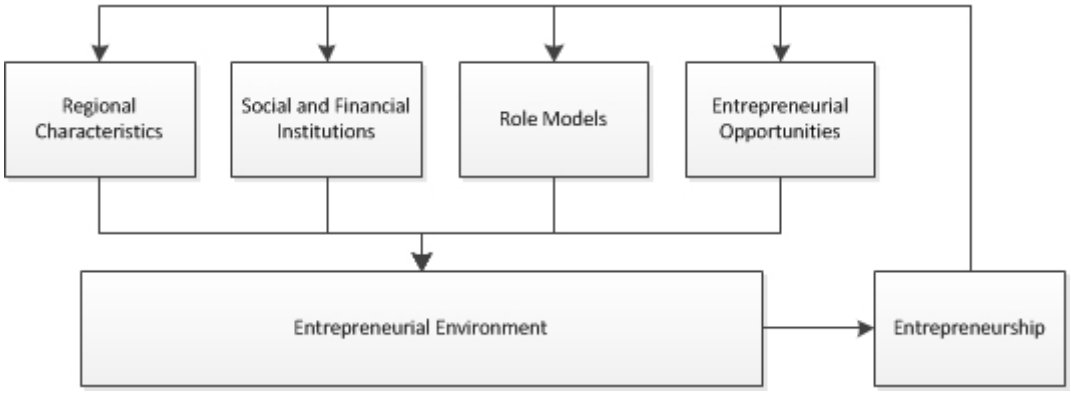


Figure 4.

2.1.3 Regional or sector specific

So far most authors have concluded that entrepreneurship is explicitly embedded within a regional context with different factors having an impact on entrepreneurship within the region. However, there is still little theory and evidence that entrepreneurship may be simultaneously linked to a regional industrial context. It is not hard to imagine that the Schumpetarian argument of creative destruction and the subsequent works on combination and allocation all are grounded within the environment of a specific sector of industry, as different sectors do not necessarily share a labor pool or share supply and demand for specific resources and services. Similarly, this line of thinking would imply that the role model argument is most likely to affect potential entrepreneurs from within the same labor pool, as they would be most likely to see each other in a relatable working environment. The reasoning in the former paragraph then does not change, nor does the visual representation in figure4 need to be changed, it should however be noted that the effect is not neutral across sectors in the region, but to a degree sector specific. In the next few paragraphs the relation between different sectors and the regional economy will be further explored, as well as the potential place of entrepreneurship and theory on entrepreneurship within the theory on agglomeration economies.

2.2 Entrepreneurship and agglomeration economies

2.2.1 Types of agglomeration economies

In this thesis agglomeration economies will, to some extent, be placed outside of the regular discussion surrounding the topic. This will be done because it is not the relative advantages of either diversity or specialization, or anything in between, that we are interested in, but rather the implied relations between the sectors in the various literature surrounding the topic.

The theory will be used to discuss the supposed relations between different sectors within the theory to combine and overlap this with the theory on entrepreneurship and path dependency. Agglomeration economies can very generally be defined as a form of economy in which an enterprise can benefit from being located in close proximity to other enterprises, both public and private (Frenken et al., 2007; McCann, 2013). A classification of different subcategories of agglomeration economies was first proposed by Hoover (1937, 1948) who distinguished between internal returns to scale, localization economies and urbanization economies. In Frenken et al. (2007) the third category, urbanization economies, is divided once more to incorporate the work of Jacobs (1969) in a related though different category as urbanization economies. In a similar fashion, it is proposed in this thesis to divide the second category, localization economies, once more to incorporate the notion of related diversity as will be explained after the general discussion of the four previously existing categories.

1: *Internal returns to scale*. In this type of agglomeration economy the benefits are usually internal to a single firm that is able to significantly lower its own production costs through sheer size. It is in its own definition not very compatible with the general concept of agglomeration economies though some effects are rather similar. It is also different from the other subcategories in that the benefits are acquired by scale in a single firm rather than by locating close to other similar firms. For a clear overview of this type of agglomeration economy see Krugman (1991).

2: *Localization economies*. In this type of agglomeration economy the benefits are not internal to a single firm but shared between firms within a sector of industry. The benefits here thus are acquired by locating in close proximity to enterprises of a shared sector of industry, which enables the enterprises in the region together to acquire the benefits of economies of scale.

3a: *Urbanization economies*. In this type of agglomeration economy the benefits are available to the general stock of enterprises in the locality due to the size of the population of both enterprises and residents. Generally speaking, more populous areas are relatively more likely to invest in knowledge generating activities, and enterprises in an urban environment are more likely to reap the benefits of the Marshallian sources of agglomeration (Marshall, 1890; 1920) than enterprises that are in a less populous locality (Frenken et al., 2007; McCann, 2013).

3b: *Jacobs' externalities*. This type of agglomeration economy is very related to the notion of urban economies and shares most of its attributes. The main difference is that Jacobs (1969) saw diversity, much opposed to the localization economies, as one of the driving forces of economic activity. Central to Jacob's externalities is the idea that the biggest learning gap is not within but

between sectors, and thus knowledge spillovers between sectors is most relevant, which geographic proximity can facilitate.

The argument of localization economies as presented here is very similar to the MAR externalities as described by Glaeser et al. (1992). In this type of reasoning the externalities are internal to one sector. However, recent literature suggests that spillovers are also likely to occur between sectors that are, as Hartog et al. (2012) put it "more cognitively proximate", and that related variety can boost the regional economic efficiency and employment growth (Frenken et al, 2007; Boschma & Iammarino, 2009). Research into related variety show that some sectors are more related to other sectors and that positive effects of the one sector can spill over to other related sectors or between sectors, for instance in terms of increases in employment or joint research. In a crude way, this can be viewed as Jacobs' externalities between a few sectors while others are excluded or at least less affected. A new category can thus be created spanning the spectrum between localization economies (absolute specialization) and Jacobs' externalities (absolute diversity), for which we propose the name related variety economies.

2.2.2 agglomeration and relatedness

So far four different categories have been distinguished between that are relevant to the relationship between entrepreneurship and the region. Localization economies, related variety, urbanization economies, and Jacobs' externalities. In this paragraph each of these will be related to the theory on entrepreneurship. It should be noted that thinking, and indeed, classifying, into rigid one-dimensional categories such as is the case here with different sectors is rather arbitrary. A good example of this is Uber, which has requested to be classified as a digital service rather than as a logistic service for institutional reasons (nu.nl, 2016). What this implies is that an enterprise can be regarded and classified in two different ways without the essence of the enterprise changing. The resulting implications are that a certain degree of relatedness between sectors can be found in research, as two similar enterprises are differently classified. The results in this case will show a certain degree of related variety, which may not be true as it can also be regarded as proof of localization economies. Nevertheless, the different categorisations do serve a purpose as we are interested in the theoretical background of differences and the actual relatedness across sectors, but it is worthwhile to realise that any conclusions should not be seen outside of this context.

The notion of localization economies follows the idea that benefits are both a regional and an explicitly sectoral phenomenon. In theory on localization economies it is proximity to similar enterprises that allows for tacit knowledge spillovers and a shared labour pool. The idea that knowledge and labour are internal to a sector are very interesting in relation to entrepreneurship theory. For instance, Verheul, et al. (2001) and Andersson & Koster (2011) established that the recognition of opportunities played an important part in the entrepreneurial environment. It can be argued that the recogntion of opportunities is, at it's base, essentialy knowledge which in theory on localization economies thus very much sector specific. In a similar fashion Fritsch and Mueller (2007) state that in an environment with many small enterprises, future entrepreneurship is more likely

because the founders of these small enterprises can act as a role model. Here too it can then be argued that the employees in these small enterprises are likely part of the same labour pool, and thus sector, as the founder. Following this reasoning, entrepreneurship and the entrepreneurial environment have a very distinct sectoral characteristic as visualised in figure5. With regards to figure5 it should be noted that the new categories, general and sectoral, do not replace the previous sources of influence such as regional characteristics, but rather the effects that these influences have can be divided into two broad categories that may overlap to some degree due to relatedness and cross-influences. The theory behind localization economies hints at a greater effect with regard to sector specific characteristics and effects on entrepreneurship.

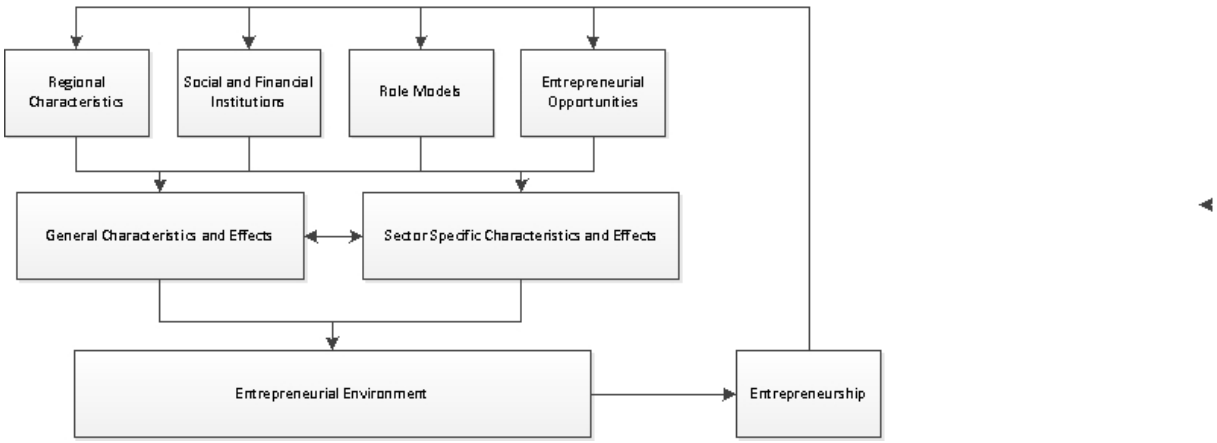


Figure 5.

Central to urbanization economies is the relevance of scale external to a single sector. The sheer size of populations of both inhabitants and enterprises in the area allows for higher public investments and an increase in market opportunities, and very likely the perceived opportunities. Urbanization economies can thus in many ways be seen as similar in effects as the localization economies, except that the benefits of scale are not sector specific. This can be related to the work of Holocombe (2003), Audretsch and Keilbach (2004), Fritsch and Mueller (2007), and Andersson and Koster (2011), who stated that the creation of new enterprises would lead to new entrepreneurial opportunities, as well as to figure4 where there is no distinction between a regional and a sectoral aspect. With regards to figure5 this would mean that there are no or little sector specific characteristics and effects that influence entrepreneurship. Differing from localization economies, this does not mean that new opportunities arise in a specific sector or in a related sector as with related diversity, but sheer size of population may create entrepreneurial opportunities across sectors that could not exist otherwise (Frenken, et al., 2007). As such, all entrepreneurship in a region is related by the size of the region. It should be noted that there is, as has been discussed previously, evidence that levels of entrepreneurship differ greatly between regions regardless of size. Therefore it is very likely that while the amount of entrepreneurial opportunities do increase with size, the entrepreneurial milieu and the perceiving of opportunities do not necessarily have to change.

Theory on Jacob's externalities is already quite closely related to entrepreneurship through innovation. Central is that a mixture of sectors, with a high level of diversity, leads to a recombination of knowledge across sectors that is more likely to spur radical innovation than knowledge drawn entirely from within a single sector (Frenken, et al., 2007). If diversity, innovation, and entrepreneurship through innovation are related across sectors, it follows that an increase in specialization may lead to less diversity, less innovation across sectors and thus to less entrepreneurship in at least a few sectors. As opposed to localization economies, the regional characteristics rather than sectoral characteristics affect entrepreneurship.

Related variety has similarities to both localization economies as well as Jacobs' externalities. The main point of related variety is that knowledge can be transferred between sectors, as with Jacobs' externalities, but the sectors have to be complementary. As such, knowledge transfer between very related sectors is likely, but, as Boschma and Iammarino (2009) put it: "… It is unclear what a pig farmer can learn from a microchip company even though they are neighbors". In other words, knowledge transfers is less likely with an increase in cognitive distance between sectors (Nooteboom, 2000). As an example, Uber, regardless of its classification in a particular sector is more likely to benefit from knowledge from the automotive industries and tech industries than from for instance the health care sector. Indeed, it is very well possible that Uber employs people from both the automotive as well as the high-tech sector, and likely also some with a background in finance. This enables the transfer of knowledge between related sectors and, to a lesser extent as it is not a small enterprise with a highly visible owner, provide a role model function across different labour pools. The implications of related variety to entrepreneurship then are that any effects that exist due to specialization in a sector can also have an effect on sectors that are different but related.

Boschma and Iammarino (2009) determine related variety as sectors that complement or share competences. This is distinctly different than looking at input-output relations, in which enterprises that are part of a production chain are related. A system often used to determine relatedness and the effects of relatedness is an entropy measure based on an hierarchical system, at firm level (Jacquemin & Berry, 1979) as well as at the region level (Frenken et al., 2007; Boschma & Iammarino, 2009). This assumes that knowledge spillovers are most prominent between subsectors of a same industry. In figure6, it is visually represented how sectors and subsectors relate to each other.

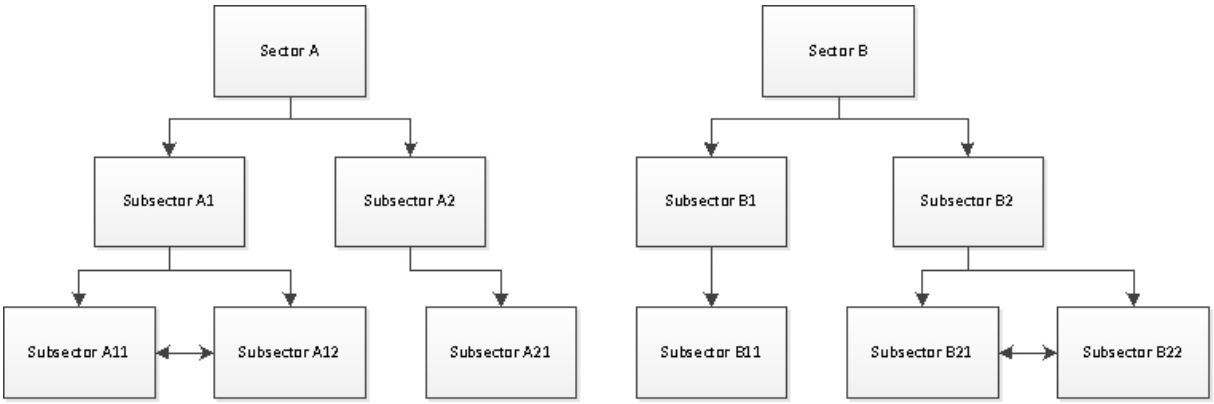


Figure 6 - Hierarchical system of sectors.

Though simplified, figure6 shows how sectors relate to each other in the hierarchical system and entropy model. Subsector A11 and A12 would be considered related in this model, as would subsector B21 and B22, as these sectors share a (sub)sector at a higher level of aggregation. Depending on the thoroughness of the entropy model and the available data subsectors A11, A12, and A21 may also be considered to be related, though less so, as they share a sector at still a higher level of aggregation, this of course also is true for subsectors B11, B21, and B22.

While all the different theories on agglomeration benefits are stylized as inherently different it is very well possible if not highly likely that one or more are present in a single region. For instance, the financial sector in London clearly does not only benefit from localization economies due to a high density of financial service enterprises in close proximity, but they also benefit from the general benefits a large city such as London has to offer. According to McCann (2013) it is thus important to distinguish what type of agglomeration effect is dominant in a region. This should however not mean that other types should be completely ignored.

2.2.3 Four hypotheses

Following the reasoning thus far, there seem to be four hypothesis with regard to Eindhoven. The first option is that there is no relation between the type of agglomeration economies and entrepreneurship. In this case there are neither general effects nor any sector specific effects due to specialization. A second option is that there are no general effects, but any effect is sector specific due to localization effects. In this case the sectors that qualify as specialized will have a relative high level of entrepreneurship when compared to their non-specialized counterparts. This means that even if there is some related variety, other sectors do not benefit in terms of entrepreneurship. A third option is that the specialized sectors show an increase in entrepreneurship, and that related sectors show a relatively large increase in entrepreneurship as well, while unrelated sectors are relatively unaffected. The fourth and last option is that there are only general effects, but no sector specific effects. In this case all sectors should show a growth proportional to one another, where the specialized sectors do not outperform the other sectors. Of the four hypothesis only three are empirically testable. The reason for this is that, following Andersson and Koster (2011), the general effects of entrepreneurship can differ between regions, and as this is a case study rather than a general study, it is thus unable to distinguish between having a general effect and having no effect.

3. Methodology

The purpose of this thesis is to provide an insight in the effects of regional specialization on entrepreneurship in the same region across sectors. This is done by providing an overview of relevant theory in the previous sector and by empirical testing in the next section. Before testing however, it is imperative to discuss and determine how the topic can empirically be studied in a way that provides relevant answers to the main question. This will be done by discussing the methodology in this section.

3.1 The sub questions and hypothesis

Two very interrelated questions have been posed that are vital to answering the main question. The first being: "How has entrepreneurship in Eindhoven developed compared to other cities in the Netherlands?" and the second: "How has entrepreneurship in Eindhoven in different sectors of industry developed in relation to each other?". The first question essentially tries to determine to what degree there is a regional effect on entrepreneurship in Eindhoven by comparing it to other cities at different time intervals. Also, it will establish what can be considered 'normal' levels of entrepreneurship for different sectors in different cities, thus creating a framework for comparison that is needed for the second question. This is necessary as, as stated before, a regional effect on entrepreneurship can be expected and thus higher rates of entrepreneurship in specialized sectors in Eindhoven could then be falsely attributed to a localization effect if this is not corrected for. The hypothesis for the first question will be:

S1.0: There is no difference in entrepreneurship between Eindhoven and the other cities.

The second question follows and expands upon the first question. After having studied and answered the first hypothesis, we will know the general effect a region has on entrepreneurship. As it is considered a regional and not a sectoral effect, it is thus assumed to be equal over different sectors. By knowing the total size of the sector, the amount of startups, and the regional effect for the different cities, we can determine if there is a difference in startup rates in a sector that can not be explained by the regional effect; ergo a regional sectoral effect. This in turn can be related to the size and the position of the different sectors as explained in the theoretical section of this thesis, with the positions being specialized, related, or unrelated. This question is thus related to the second part of the theoretical framework that theorizes that there may not only be a regional effect on entrepreneurship but also a sectoral effect. There are then three testable hypothesis, which are:

S2.0 Specialization has no effect on entrepreneurship in general.

S2.1 Specialization in a sector has no effect on entrepreneurship in that sector.

S2.2 Specialization in a sector has no effect on entrepreneurship in other related sectors.

3.2 Discussing the components

Several important components of both the theory and the empirics need to be thoroughly discussed, and several choices need to be thoroughly motivated as they have large implications on the tests and the results. These components include the definitions of specialization and related variety, but also the choice of regional scale and time frame.

3.2.1 Determining specialization and related variety

When discussing the effects of specialization on entrepreneurship it is obviously important to determine exactly what specialization is, and how this can be measured. Several different measures can be used to determine whether a region is specialized as a whole. Dewhurst and McCann (2002) give a good overview of several different measurement techniques, both for absolute and relative specialization. For this thesis it is, however interesting, not necessarily important to determine to what degree a city is specialized, but rather to what extent sectors in a city are specialized. Therefore, rather than comparing the aggregate of shares in different sector against a national average, we are interested in to what degree the share of sector of industry in a city differs from what can be expected in such a city. A sector can thus be labeled as specialized within a region when the share of that sector in that region is significantly larger than what can be expected. This share can be measured in two different ways. The first is based on the population of enterprises in the area, and the second is based on the population of employees working in the specific sector. Following the role model argument, the former is more interesting and as such will be used in this thesis.

Determining what constitutes related variety is slightly more challenging than determining specialized sectors. The reason for this is that it demands a knowledge of what sectors are more related than others. A priori this can be determined by looking at relatedness at a sectoral digit level (Frenken, et al., 2007). This is very similar to the entropy measure based on the hierarchical model discussed in section section 2.2.2. For this, the SBI-codes, which classify every enterprise in the region to a (sub)sector will be used for a simplified version of the entropy model. In this model, sectors that are considered different at a lower level but share a higher level are considered related.

A second method of determining which sectors are related would by looking at which sectors show a relatedness in growth or decline. In this manner relatedness can thus necessarily only be determined after examining the data. Both ways of determining relatedness have their own strengths and weaknesses. For instance, the first manner is highly arbitrary. Again, following the case of Uber, this enterprise and many amongst its subsector are likely to be influenced by seemingly unrelated sectors through a classification bias. Thus seemingly unrelated enterprises, and by extend subsectors, may in fact be related. The second manner is subject to an entirely different biases. If a sector's growth correlates well with the growth in a specialized sector this does not necessarily mean a causal relationship. It may in fact be chance or a sectoral effect that is unrelated to the growth of the other subject sector, or related to an entirely different sector between which we are not able to differentiate. Another problem with this method is that growth might be related to entrepreneurship, and thus a bias is created in which relatedness might in part be determined by entrepreneurship which is also the subject of this research so a self-fulfilling prophecy is created. A point of critique then is that relatedness is defined by growth, while this thesis attempts to

determine whether relatedness causes growth, creating an entirely new but rather unavoidable bias. In this thesis the first option will be used primarily as it is both theoretically more sound and better embedded in the theory.

In this thesis specialization is then determined by comparing the size of a sector to the mean of the sector size in relation to the city economy. When a sector in a specific city is two times the standard deviation above the mean at SBI three digit level it is regarded as specialized in that specific city. Sectors that are not specialized but that share an SBI two digit code with a specialized sector are regarded as related. Of importance is then that this research does take little account for absolute size of sectors with regards to being considered specialized. It is theoretically very well possible that a sector is regarded as specialized in one city due to having a high share in the economy, while not being regarded as specialized in another city in which the absolute size of the sector is larger. However, as the standards for being considered specialized are rather high and the city size does not differ so much this is unlikely to occur. It is also important to note that each sector can only belong to a single group. This means that if two sectors are both considered specialized at the three digit level that share a sector at the two digit level, they are not considered related.

3.2.2 Defining regions

When determining in which sectors a region is specialized, it should first be established what exactly constitutes the region. For this thesis Eindhoven is used very much as a case study, and as it is empirically important to compare Eindhoven to other cities, all of these regions need to be defined both properly as well as similarly. For Eindhoven there are two obvious definitions of the region. The first is based on figure1 and encompasses the entirety of the Eindhoven as well as several communities in the direct vicinity that belong to the same economic area. The second definition is simply the municipal border. While the first option logically is the more complete option, it is also the most difficult to define. For instance it remains unclear whether the 21 communities in figure1 are all truly related and whether they are the only parts of the economic area. This becomes an even larger problem when comparing Eindhoven to other cities as a similar judgement must be made for the entirety of the selected cities used for comparison. Therefore, the second more pragmatic option is used in this thesis. It should be noted that the rest of the economic area can to some extent be included by focusing on sectoral employee population rather than on sectoral enterprise population, thus including commuting from outside of the city borders.

Besides the general determination of what a region is, a specific choice of cities with which to compare Eindhoven needs to be made. Ideally, these cities need to be rather similar to Eindhoven both in function and size. The four cities used as comparison, all in relative close proximity to Eindhoven (225,020 inhabitants), are Tilburg (212,943 inhabitants), Breda (182,424 inhabitants), Nijmegen (172,322 inhabitants), Den Bosch (151,752 inhabitants), and Arnhem (152,180 inhabitats).

3.2.3 The timeframe

As we are interested in the effects of specialization on entrepreneurship, there is necessarily a time element as we need to see how entrepreneurship develops in the region over a prolonged period of time. A second reason to study the effects over a larger period of time is to make sure conclusions are not drawn based on incidental shocks to the local economic structure, such as the bankruptcy of a single large firm having a large impact on a specific sector or a sudden change in the viability of a certain sector for other reasons, known or unknown. This means that a timeframe is needed that is large enough to see effects of specialization on the economic structure of the region, and large enough to check for shocks in the area. Ideally, an annual overview of the different communities and their respective sectors is needed for a period of time of at least ten years, but preferably longer.

The data set that is made available for this research fortunately contains data over a prolonged period of time. However, as we are interested in sectors at the sbi03 level at which, as discussed before, sector details are highly specific, certain sectors tend to be rather small and thus the impact of a single startup on the data can be exceptionally large. Therefore, rather than looking at a single year at a time the choice has been made to aggregate the available data to different periods each consisting of three years. In these time periods the data contains the average of the three years, meaning that in a certain aggregated time period it is possible to have non rounded off numbers for existing enterprises or startups. The five timeframes that are used are 2001-2003, 2004-2006, 2007-2009, 2010-2012, and 2013-2015. Data from 1998 to 2000 is not used because data on startups is not available for 1998 and thus an equal sized time period could not be created prior to the first block starting in 2001. In certain graphs data prior to 2001 will be shown if possible for reasons of clarification but no testing has been done using this data.

3.2.4 Measuring entrepreneurship

After having defined the other usable concepts, ergo the region and the timeframe, defining entrepreneurship becomes rather easy, with the keyword being ‘new’. That is; any enterprise that is ‘new’ at a certain point within the timeframe and within the specified region can be considered to be an indicator of regional entrepreneurship. Ideally, we would be able to specify between different types of entrepreneurship as this may offer valuable insight in whether the changes in entrepreneurship are due to changes from within the region or for instance because the regional economic structure is attractive to actors from without the area. Nonetheless, it remains interesting to look at what the effect of specialization is on entrepreneurship, if any, without specifying the origins of each particular case of entrepreneurship.

Furthermore, each case of entrepreneurship needs to be classified. Without this necessary but arbitrary classification, it is impossible to define in advance what sectors can be considered specialized as becomes clear in subsection 3.2.1, but also changes per sector over time can not be measured. Subsequently this means that even as the definition of a region, the definition of sectors must ideally be consistent for the entirety of the timeframe, otherwise drawing a comparison will be problematic. As hinted at before, using the SBI-code system seems ideal as long as this consistency can be assured.

To answer the main questions of this thesis, entrepreneurship needs to be compared. For the first question, which discusses whether Eindhoven differs from other cities, this can be done rather straightforward by comparing the city startup-rates. The city startup-rates here are simply defined as the amount of startups per existing enterprises. This allows us to determine a city wide effect. For instance, if Tilburg would have a startup-rate equal to 106% of Eindhoven, we can correct for the city effect by downsizing Tilburg's startup-rates at sector level relative to the city wide startup-rate. It should be noted that an important and influential choice that has been here that the city effect enhances the existing startup-rates by a specific amount rather than that it is equally distributed across all existing sectors.

For the second question, which discusses the influence of specialization and variety, this is not so simply done as this needs to be compared at sector level. As we are trying to test whether there are differences within sectors due to specialization or relatedness to a specialized sector, different sectors can not be compared to an aggregated whole. Instead, startup-rates are compared to a mean of the startup-rates of the same sector across different cities in the same year, after having been corrected for a city effect. By comparing the startup-rates to the mean of the same sector we can then see the effect of specialization or relatedness on the startup-rates. Recall that startup-rates are defined as the amount of startups per existing enterprises, and specialization is defined as having a large relative share of the regional economy. Thus, if none of the groups has an average startup-rate that differs from the mean then specialization, being the relative share in the local economy, or being related to a specialized sector has no influence on the startup-rates. However, this also means that a sector that is specialized is still likely to have a relatively large absolute amount of startups as not differing from the mean means equal startup-rates which, again, is expressed as startups per existing enterprises.

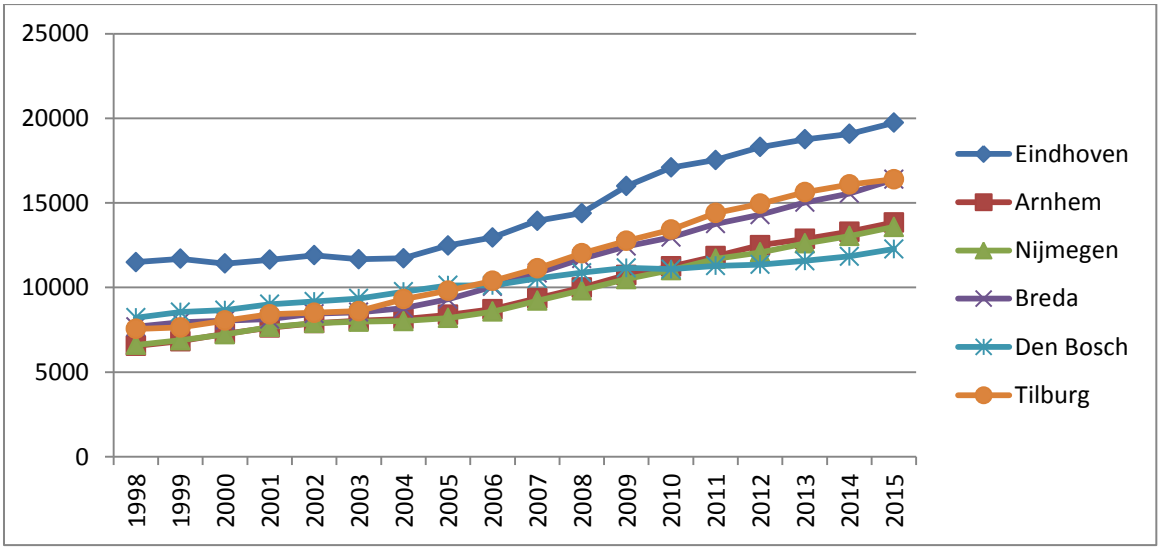
4. Results

To summarize, the data set used contains city-level data on enterprises for six different cities in the southern part of the Netherlands, around the city of Eindhoven. Startups are defined by the year of entrance into the data set rather than by different startup criteria. The data has been aggregated to the SBI three digit sector specific level to allow comparisons at that specific level and to determine which sectors can be considered specialized as defined in this thesis. A higher level, the SBI two digit level, is used to determine related sectors.

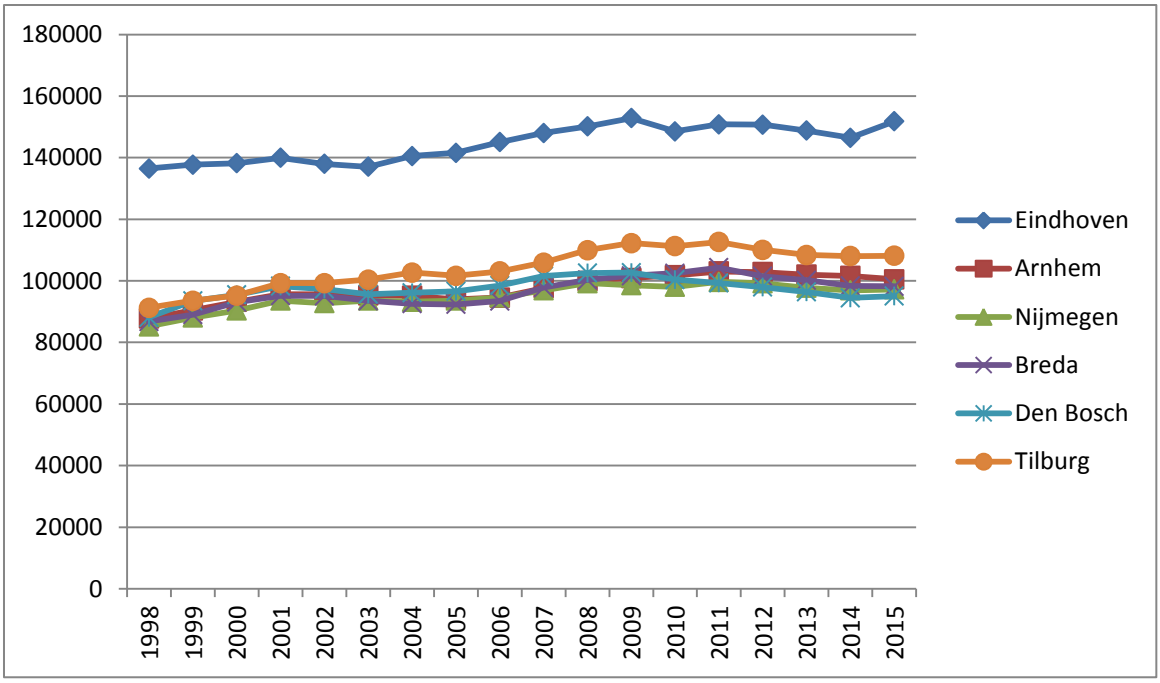
4.1 City-level comparison over time

At city-level the six cities that are subject of this research show a growth in total amount of enterprises that is rather similar as well as consistent, as can be seen from graph 1. The same holds true for the total amount of jobs in the city as seen from graph 2. In both aspects Eindhoven is clearly the largest but the absolute difference with the other city remains more or less unchanged. Den Bosch does seem to be a rather curious case as its position relative to the other cities seems to be worsen after 2009.

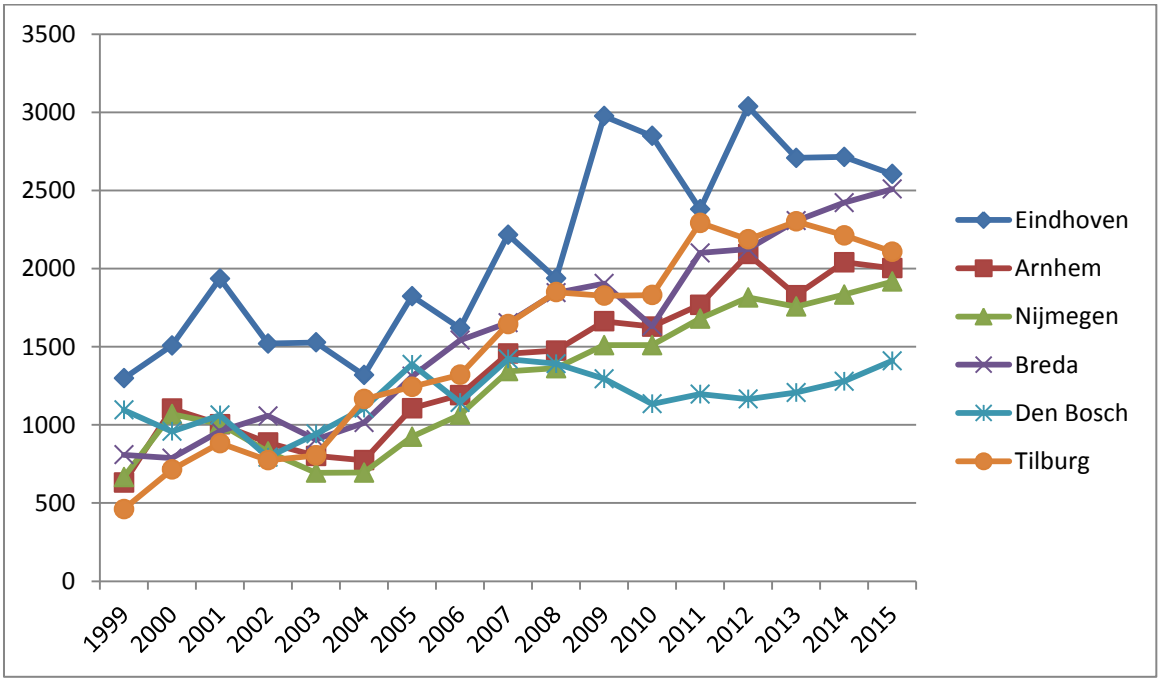
Graph 3 and graph 4 respectively show the absolute and relative startup-rates per city over time. Even though the startup-rates do seem to be quite volatile over time, the volition does seem to be similar between cities. Again, in absolute numbers Eindhoven is unsurprisingly the largest. However, relatively this is not necessarily nor continuously the case. Here too, Den Bosch differs quite a bit from the other cities by showing both low absolute as well as relative start-up rates starting from around 2007. Table 1 shows the relative startup-rates, measured as the amount of startups per existing enterprises for each year in each city. This data is used to compensate for the regional effect by adjusting the sector startup rates by dividing them by the regional startup rates and multiplying by hundred.



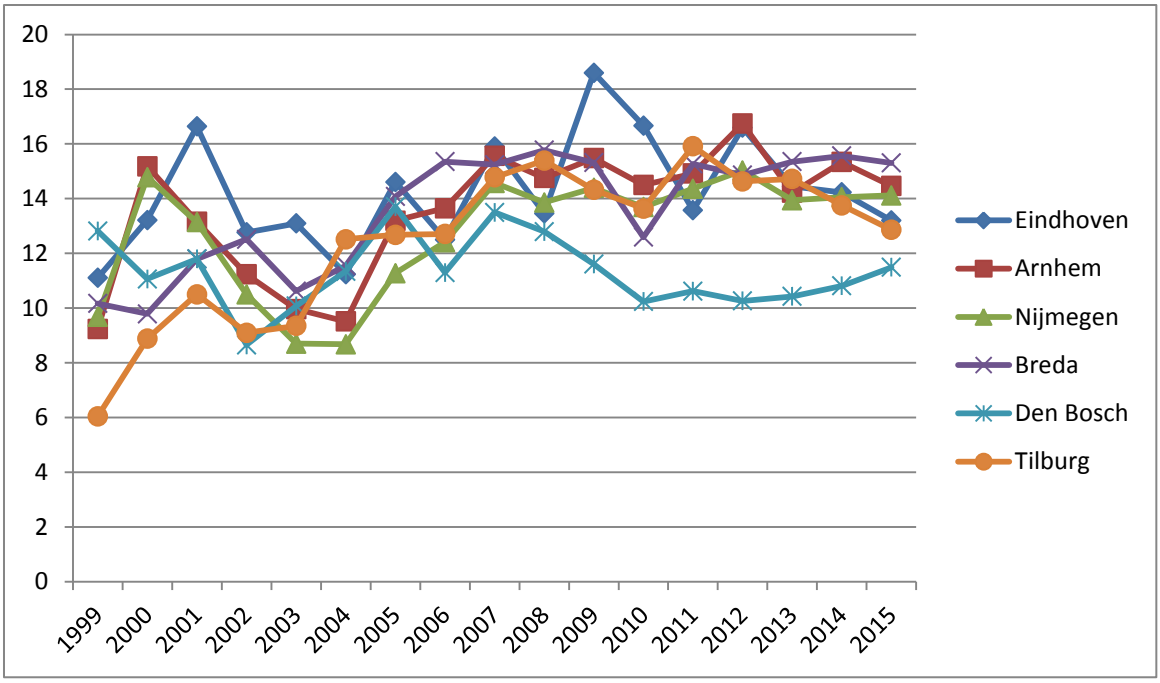
Graph 1: Total amount of enterprises over time.



Graph 2 – Total amount of jobs over time.



Graph 3 - Total amount of startups over time.



Graph 4 - Startups per existing enterprises over time.

4.2 General effects of specialization and related variety on entrepreneurship

For the general effect of specialization over the entire period of time across all cities and sectors, the distribution is as shown in table1. A single case from here on consists of a single sector in a single city in a three year time period as explained in section 3.2.3. The non-specialized group, sectors that are neither specialized nor related to a specialized sector at the sbi02 level are by far the largest group as could be expected. The related group is not itself specialized at the sbi03 level, but does share a sector with a specialized sector at the sbi02 level. The specialized group consists of sectors that are considered to be specialized following the definition of this thesis. Slightly above 2.5% of the cases are missing due to the fact that the effect is measured as a percentage of the mean. This means that if there is no mean, due to the sector having no counterpart in another city, or the mean being zero, due to there being no startups in that particular sector in all cities, this leads to a division by zero error resulting in a missing case. Similarly, if there is a given mean for a sector, but the sector has no startups in a specific city, the score will return 0 resulting in a rather large portion of the population being classified as having zero percent of the mean, especially in the non-related and non-specialized group. Table 1 shows the distribution of the different groups as well as the mean, standard deviation and standard error. The mean is slightly above the expected 100% because all cases are included in determining the average startup-rates, but are excluded later due to being labeled as missing cases, which happens relatively often in consequent paragraphs.

	Cases in group	Mean	Std. Deviation	Std. Error
Non-specialized	3135	95,6651	64,56312	1,15310
Related	457	114,6354	76,26324	3,56744
Specialized	317	165,8240	101,53614	5,70284
Total	3909	103,5724	72,34578	1,15713

Table 1 – Distribution of cases in the different groups across all cities.

Unfortunately, the data is neither normally distributed nor can equal variance be assumed. Despite being rather robust, it is debatable whether a one-way analysis of variance could or should be used to compare the different groups instead of a non-parametric variant. However, as a one-way analysis of variance tends to be more descriptive than its non-parametric counterpart, it is still used with the Games-Howell post-hoc test, along with a Kruskal-Wallis test. The results of the one-way analysis of variance are shown in table2, the results of the Kurskal-Wallis test can be found in attachment1.

The tests use the same data as table1 and as such the cases in the group remain the same. Both tests show a significant difference in means between the three different groups at the 0,05 level and the 0,01 level. However, as can be seen in table2 the standard deviation for all groups is more than half of their mean. For the specialized group this means that the mean of the other groups is less than one standard deviation away from its own mean as can be seen in table1. The difference between the related variety group and the non-specialized group is even smaller than half of its standard deviation. The results thus show there is a significant difference in means, however, due to the fact that the data is not normally distributed it is likely to be difficult if not almost impossible to make predictions for an individual case based solely on whether a sector is considered specialized per the definition of this thesis.

Group	Comparison Group	Mean Difference	Std. Error	Sig.
Non-Specialized	Related	-18,97027	3,74917	,000
	Specialized	-70,15891	5,81825	,000
Related	Non-Specialized	18,97027	3,74917	,000
	Specialized	-51,18864	6,72674	,000
Specialized	Non-Specialized	70,15891	5,81825	,000
	Related	51,18864	6,72674	,000

Table 2 - One-way ANOVA comparing the means between groups with Games-Howell post-hoc.

Based on the theory it could be expected that specialization and relatedness would positively influence entrepreneurship at sector level. This seems to have been confirmed here for the combination of Eindhoven and the control group together based on table 2. Recalling the third the hypotheses put forward in section 2.2.3 the third one, where specialized and related sectors have an increased startup-rate, seems to best fit the data in general for all of these cities together.

4.3 The effects of specialization and relatedness on entrepreneurship in Eindhoven

When looking at Eindhoven, there are 65 cases of specialization over time. However, quite often two or more cases are in fact the same sector but in different years. When looking at individual sectors there are 28 different sectors, meaning that it is not uncommon for a sector to lose its specialized status following the criteria of this thesis. When looking at related variety there are a total of 107 cases, with 48 individual sectors reflecting the changes in the specialized sectors. As can be seen in table3, the data for Eindhoven is comparable with the general data, with Eindhoven showing higher means and similar standard deviations. The higher means are agreeable with the data in that Eindhoven has a generally higher startup-rate, but can also be due to Eindhoven having a relatively high amount of missing cases.

	Cases in group	Mean	Std. Deviation	Std. Error
Non-specialized	558	120,9849	77,15848	3,26638
Related	107	156,7387	81,49239	7,87817
Specialized	65	182,1740	91,35831	11,33160
Total	730	131,6739	81,57332	3,01916

Table 3 - Distribution of cases in the different groups in Eindhoven.

A major difference is that the specialized and related groups are not significantly different in the one way analysis of variance as can be seen in table4, and neither are they at the 0.01 level using a Kruskall-Wallis test as can be seen in attachment2.

Group	Comparison Group	Mean Difference	Std. Error	Sig.
Non-Specialized	Related	-35,75380	8,52847	,000
	Specialized	-61,18908	11,79298	,000
Related	Non-Specialized	35,75380	8,52847	,000
	Specialized	-25,43528	13,80111	,160
Specialized	Non-Specialized	61,18908	11,79298	,000
	Related	25,43528	13,80111	,160

Table 4 – Comparison of the means of the different groups using a one-way ANOVA with Games-Howell post-hoc.

Similarly to the previous section on the relation between specialization and relatedness on entrepreneurship for Eindhoven and the other cities in general, table 4 shows that specialization and relatedness at sector level has a positive effect on entrepreneurship. Again, the third hypothesis as put forward in section 2.2.3 seems to be the best fitting option. This implies that in both cases, in general and for Eindhoven specific, it is likely that sources that influence entrepreneurship seem to have a sector specific characteristic. However, it remains very much unclear what contributions the individual sources have on entrepreneurship at sector level. Recalling the theoretical framework and figures 4 and 5 from section 2.2.2 it seems reasonable to assume that some, such as role models and

entrepreneurial opportunities, are more likely to be sector specific than financial and social institutions but as to this there can be no definite conclusion based on this research.

To discuss the effects of relatedness on entrepreneurship in Eindhoven further, it is worthwhile to discuss which sectors are determined to be specialized and which are determined to be related besides having discussed how this has been determined. By doing so it becomes clear where and why the specialized and related variety groups are no longer significant at the 0.01 level in Eindhoven regarding the total amount of startups. With regards to Eindhoven, details on the exact levels of entrepreneurship in the sectors that are considered specialized and related and further details on the exact level of entrepreneurship can be found respectively in attachments 6 and 7. In attachments 6 and 7 the list of specialized sectors and related sectors are shown. Each case, which consists of a sector in a city in a three year period, can only belong to one group, either non-specialized, specialized, or related to a specialized sector. But sector that are specialized in one year can be non-specialized or related in another year. In attachment 7 the cases that are considered related but are at one time also considered specialized are highlighted in yellow.

Several interesting observations can be made based on the data presented there that will likely come as no surprise. First, though it has been stated here before that both Eindhoven as well as the Netherlands have stated a specialized in a high tech systems and machines sector, which is as such nonexistent within the data resources or the classification systems used by the very same city and country. Nonetheless, the data shows that a large part of the specialized sectors are named as something which fits well under the umbrella of high tech systems and machines, while most other sectors that are considered specialized are generally services that are likely considered specialized due to the fact that Eindhoven is a relatively big city as compared to the others and as such may have a better developed service industry than the other cities. Alternatively, this may just be that Eindhoven simply also has some unrecognized specialization in those sectors. Secondly, many of the sectors that are considered related are at one point also considered specialized themselves. This is unsurprising as relatedness is based on not being specialized but being related to a specialized sector, which is determined per three years. Thus, the raw data seems to support the idea and the results that related sectors and specialized sectors in Eindhoven are indeed very related to a large extent. It also should be noted that the sectors that are considered related can also, as could be expected, placed under the umbrella of high tech systems and machines.

4.4 General effects of specialization and relatedness on the amount of jobs in startups

Regardless of there being more entrepreneurship or not in specialized and related sectors, this does not automatically mean that there is a relative change in the amount of jobs in startups in those sectors as well. When looking at the effects of specialization and relatedness on entrepreneurship this is, however, very interesting. Using the same dataset we find that, generally speaking the groups here too are not normally distributed and equal variance can not be assumed. The results of the one-way analysis of variance with Games-Howell post-hoc test is shown in table 5, and a Kruskall-Wallis test can be found in attachment 3 .

Group	Comparison Group	Mean Difference	Std. Error	Sig.
Non-Specialized	Related	-20,48551	5,74710	,001
	Specialized	-71,88455	8,24035	,000
Related	Non-Specialized	20,48551	5,74710	,001
	Specialized	-51,39904	9,71775	,000
Specialized	Non-Specialized	71,88455	8,24035	,000
	Related	51,39904	9,71775	,000

Table 5 – Jobs in startups compared to the mean for all cities.

The results are rather similar to those regarding the differences in startups between the different groups. Here too do we find a significantly higher mean for the specialized and related groups. This shows that there are not only more startups, but also relatively more jobs in startups in specialized and related sectors. A separate Kruskall-Wallis test has been done to establish whether there is any difference in average amount of jobs per startup between the groups, the results of which are not significant between the non-specialized and related groups, but is significant for the other groups as can be seen in attachment 4. This indicates that to some degree there are not only differences in the amount of startups, but also how startups in specialized sectors 'work' as compared to the other sectors. Alternatively, the difference may be due to other factors such as what kind of enterprises contribute to the numbers, recall for instance that there is no distinction made between a local startup with a of couple employees and a local investment of opening a new factory with several hundreds of jobs.

4.5 The effects of specialization and relatedness on jobs in startups in Eindhoven

To test whether the effects of specialization on jobs in startups differ from the general effect further tests have been undertaken. As equal variance, surprisingly, can be assumed here a one-way analysis of variance has been used with a Bonferroni post-hoc test. The results are shown in table 6.

Group	Comparison Group	Mean Difference	Std. Error	Sig.
Non-Specialized	Related	-38,82783	13,34468	,011
	Specialized	-68,39043	16,57122	,000
Related	Non-Specialized	38,82783	13,34468	,011
	Specialized	-29,56260	19,88196	,412
Specialized	Non-Specialized	68,39043	16,57122	,000
	Related	29,56260	19,88196	,412

Table 6 – Jobs in startups compared to the mean for Eindhoven.

Table 6 shows that there are significantly more jobs in startups in specialized sectors than in non-specialized or non-related sectors. However, the difference between the specialized sectors and the related sectors is no longer significant at any level, and neither is the difference between the related sectors and the non-related and non-specialized sectors at the 0.01 level of significance. A separate Kruskall-Wallis test has been done to establish whether there is any difference in average amount of

jobs per startup between the groups which is not the case. These test results can be found in attachment 5. This indicates that Eindhoven may in this regard be different from the general results, as the results are all not significant. This in turn may be very well be due to the final point made in section 4.4. As there is no distinction made between startups these numbers can vary quite extensively. Thus, the result that there are no differences in the amount of jobs per startup should at best only be seen as an indicator that the effect specialization has on entrepreneurship is solely on the amount of startups and not in differences in the between types of startups, but the results should by no means be seen as a definitive result.

5. Conclusion

In this thesis the relation between specialization at sector level and entrepreneurship in Eindhoven has been central. With regards to specialization not only sectors that are specialized themselves, but also those sectors which can be considered related to specialized sectors have been examined. To establish the effects of specialization on entrepreneurship in Eindhoven at sector level, each sector in Eindhoven has been compared to the mean of it and its counterparts in Eindhoven and five other nearby and similar cities. With regards to the effect of specialization and relatedness on the amount of startups it can be concluded that both specialized and related sectors show significantly higher rates of entrepreneurship than their non-related and non-specialized counterparts. The average of amount of jobs per startups does differ between the groups as well. In general, amongst Eindhoven and the cities used for comparison, the groups differ with there being more jobs per startup in the non-specialized and non-related group, with the least amount of jobs per startup in the specialized group. When testing using between group comparisons the group consisting of sectors related to specialized sectors do not significantly differ from the non-specialized non-related group. When looking only at Eindhoven the results are again roughly the same though this time the differences between groups is not significant for any group. It can thus be concluded that specialization leads to more startups in the sector and in related sectors, it can however not with certainty be stated that specialization or relatedness has a significant impact on the amount of jobs in startups in sectors.

In this thesis it is implicitly assumed that there are no differences in the types of startups between the sectors. If this is indeed true, which can at best cautiously be assumed, this means that various factors such as regional characteristics, social and financial institutions, role models and entrepreneurial opportunities do not have an equal effect across sectors. Nor should it thus be assumed that entrepreneurial path dependency is a fully regional effect. Instead, these factors are to a degree sector specific and seem to benefit the sector of origin and sectors that are closely related comparatively more than non-related sectors. It should be noted that the full extent of factors and characteristics that can be related to entrepreneurship is likely much larger than those put forward in this thesis. Also, no definitive answer is offered as to which factors have what kind of effect and whether this effect is sector specific or more general.

6. Discussion

6.1 On specialization

Both for the general area including the total of Eindhoven and the surrounding cities, all theory and evidence points towards an effect of specialization on entrepreneurship. However, due to large amount of differences within the groups all data should be interpreted with a fair amount of care. These differences are very likely due to the fact that not all sectors respond the same to specialization, defined as having a large local share, based on sector characteristics. For instance, it can be argued that enterprises that can gain advantages at the regional level but compete at a global level reap more benefits from local specialization than enterprises which have to compete at the regional level, in which case specialization as defined in this thesis would very likely mean a very saturated regional sector market. Furthermore, some sectors will simply have a larger relative share because of the differences in city size. For instance different types of public transportation are included, and Eindhoven is overrepresented in some of these sectors as well, likely because it is more of a transportation hub than the other cities. In the case of public transportation entrepreneurship is extremely unlikely and this will thus influence the data. Another influence on the data is that sectors are compared to the mean of the same sector across cities in the same year, but the specialized sectors are included in establishing this mean. Thus the exact effect of specialization is likely slightly underestimated in this thesis. All of these aforementioned problems are the result of the fact that there are no a priori assumptions made as to which sectors are specialized, which can thus be considered both a strength and a weakness of this study.

6.2 On relatedness

What becomes clear by looking at the data is that neither specialization nor relatedness, and perhaps even not what comprises a sector, should be considered to be an absolute. For instance, almost all sectors that together comprise sector 26 at sbi02 level, the production of computers and electronic and optic devices, are at one point considered specialized though with little consistency. Sector 27 however is by the definition of this thesis not related, even though it is not difficult to imagine that the production of electric devices, such as the production of electric and electronic cables and switches which at a point is considered to be a specialized sector, should in fact be very related. Similarly, the production of machinery and the wholesale of machinery are both at one point considered specialized, but the sectors are never considered related to each other, even though both show above average startup-rates. This problem originates from the hierarchical system in which sectors are classified as explained in sector 2.2.2. Ideally, an absolute and objective measure as to how sectors relate would be established, though this is highly unlikely to be attempted nor is it likely to succeed as what constitutes a sector may differ between and within countries. For instance, Uber would be related to other sectors differently than the 'regular' enterprises with which it shares a sector, both as a financial enterprise as well as when classified as a financial enterprise. This does not mean there is no room for improvement regarding organization of sectors and the way sectors related to each other, nor does it excuse researchers from attempting to establish better ways to determine how exactly sectors relate.

6.3 On diversity

This thesis forgoes any conclusion as to effects of diversity by focusing solely on specialization. The main benefit of this is that it allows us to have an in-depth look at the effect of specialization and relatedness at sector level, and discuss what comprises or should comprise a sector. In this thesis it has been established that specialization and being related offer benefits with regards to entrepreneurship. What has not been, and can not be, concluded is what the effects of diversity are on entrepreneurship. It may very well be that specialization offers precisely that; specialization of entrepreneurship in a single field (including related sectors to some extent). This does not mean that Jacobs' externalities do not exist. In fact, the overall level of entrepreneurship in a city may be lower in cities with a high degree of specialization in one or a few sectors. As to this, no answer is offered in this research. This is however a very interesting question and not just scientifically. Assuming that both are true; Jacobs' externalities offer higher entrepreneurship overall, and specialization offers a very high level of specialized entrepreneurship, but a lower overall level, which configuration of the regional economy can then be considered a 'best'?

6.4 On sources of influence

Within the theoretical framework of this thesis several sources or factors of influence have been determined, all of which are well grounded in theory and are likely to affect entrepreneurship to some degree. Examples are the regional characteristics, the role models, the social and financial institutions, and the entrepreneurial opportunities. While on of the central questions of this research has been to determine whether they had not only a general but also a sector specific effect, several new important questions have been left unanswered as of yet. First, it should be noted that these sources of influence have in this thesis been used as indicators and examples as to why there might be a sector specific effect. What has not been attempted or done is to give a full overview of which factors are at work in Eindhoven, nor has an answer been provided as to what effect belongs to which specific element. For instance, it has been stated that regional characteristics are a factor, which they in truth are likely to be. But the exact impact of these regional characteristics, which may include average age and level of education, on the region as compared to the effect of the other factors remains entirely unexplored. Similarly, it has not been discussed to what extent each of the sources of influence has a general effect and to what extent the effects are sector specific, though these are very valid questions.

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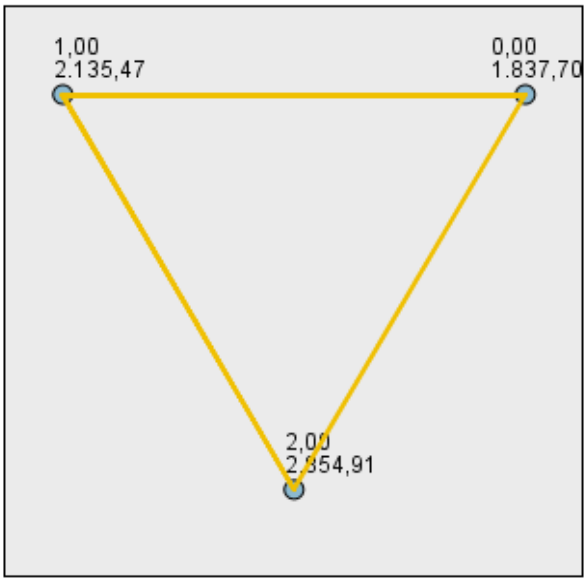
7. Attachments

Attachment 1 - General effects of specialization and related variety on entrepreneurship.

Pairwise Comparisons of specialisatie



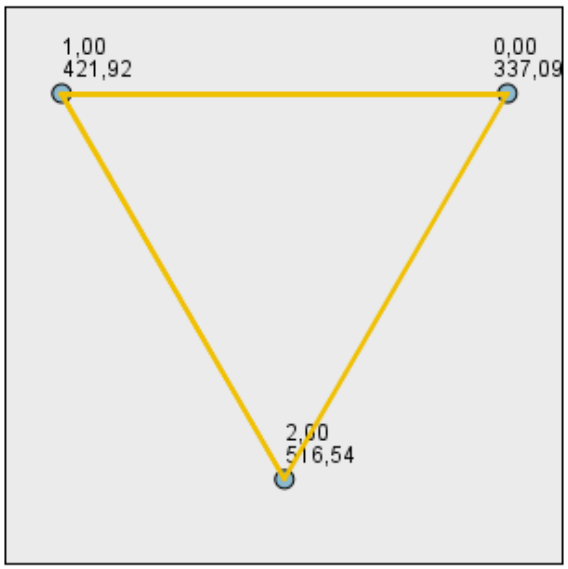
Each node shows the sample average rank of specialisatie.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
0,00-1,00	-297,774	56,477	-5,272	,000	,000
0,00-2,00	-1.017,219	66,476	-15,302	,000	,000
1,00-2,00	-719,444	82,445	-8,726	,000	,000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Attachment 2 - The effects of specialization and relatedness on entrepreneurship in Eindhoven.

Pairwise Comparisons of specialisatie



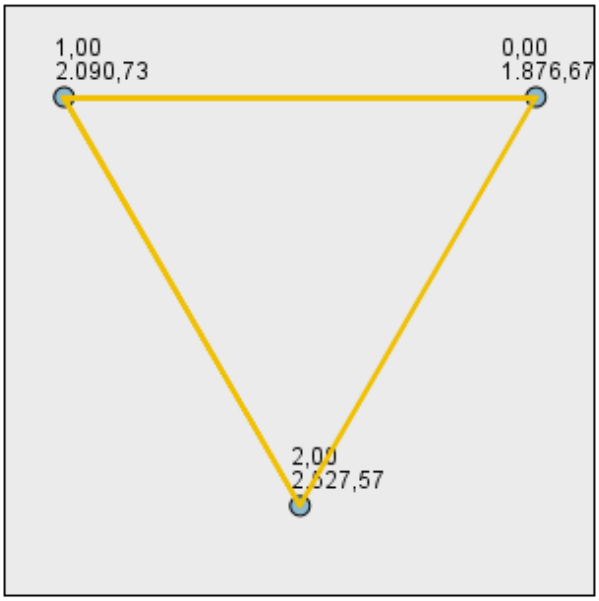
Each node shows the sample average rank of specialisatie.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
0,00-1,00	-84,828	22,247	-3,813	,000	,000
0,00-2,00	-179,451	27,627	-6,495	,000	,000
1,00-2,00	-94,623	33,150	-2,854	,004	,013

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Attachment 3 – General effects of specialization and relatedness on the amount of jobs in startups.

Pairwise Comparisons of specialisatie



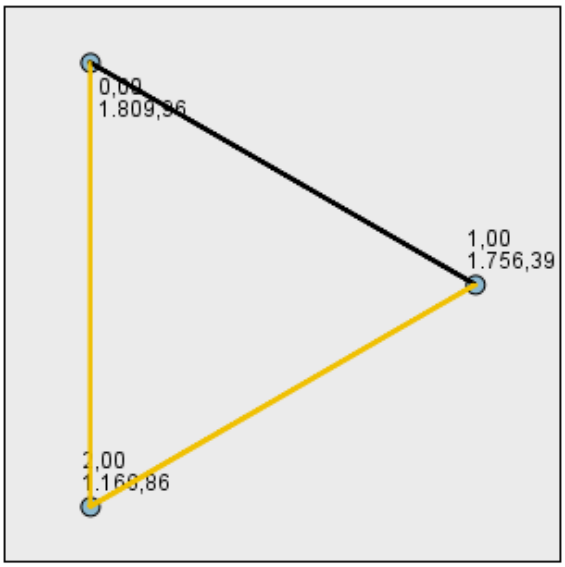
Each node shows the sample average rank of specialisatie.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
0,00-1,00	-214,065	56,462	-3,791	,000	,000
0,00-2,00	-650,897	66,459	-9,794	,000	,000
1,00-2,00	-436,832	82,421	-5,300	,000	,000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Attachment 4 – General effects of specialization and relatedness on the amount of jobs in startups.

Pairwise Comparisons of specialisatie

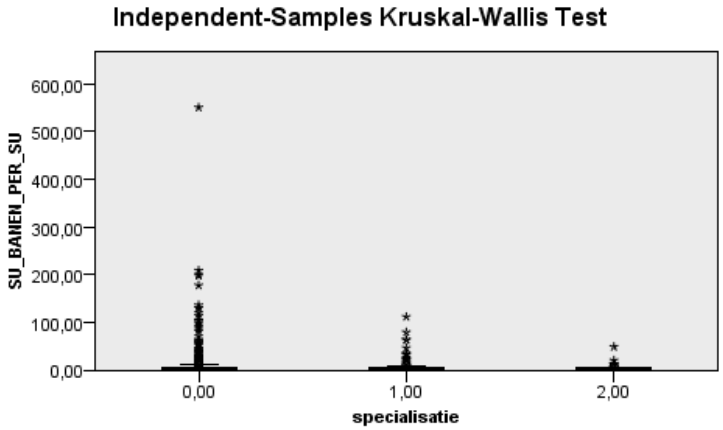


Each node shows the sample average rank of specialisatie.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
2,00-0,00	643,096	62,237	10,333	,000	,000
2,00-1,00	589,526	76,939	7,662	,000	,000
1,00-0,00	53,570	52,717	1,016	,310	,929

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Attachment 5 –The effects of specialization and relatedness on jobs in startups in Eindhoven.



Total N	730
Test Statistic	4,082
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	,130

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Attachment 6 – Details on entrepreneurship in specialized sectors.

			Total amount of enterprises in year aggregate					Startup-rates compared to mean in year aggregate				
SBI02	SBI03		2001-2003	2004-2006	2007-2009	2010-2012	2013-2015					
17	171	Production of paper and cardboard				3				0		
26	261	Production of electronic components		15	17	16,67	16		332,71	260,3	281,51	524,31
26	262	Production of computers and accesories	10,33	11,67	8,33		8,67	87,72	321,09	0		240,6
26	263	Production of communication devices					3,67					71,49
26	264	Production of consumer electronics	7,67					0				
26	267	Production of optic instruments and	5,67					353,6				
27	273	Production of electric and electronic cables and switches					2,67					413,1
28	289	Production of heavy machinery			15,33					190,22		
29	291	Production of cars				5					241,11	
29	293	Production of car parts and accesories	6					121,16				
41	411	Land development enterprises	57	46,67	51			206,14	214,16	149,88		
46	465	Wholesale of ICT devices	244,33	249,67	223			217,16	219,72	187,65		
49	493	Transportation of persons		41,33	61,67	85,33	91		210,53	186,89	175,6	150,18
62	620	Services in information technology	540	611,67	823,67	1026	11,54	166,69	140,8	151,35	160,98	159,67
64	649	Financial intermediation	41,67	34,33				345,14	309,53			
66	661	Financial advisory services	72,33		72,67	67		173,74		182,94	177,73	
66	662	Insurance services		142					174,1			
68	681	Real estate trade	51,67	32,33	39	41,67		203,08	222,86	210,68	221,16	
71	711	Architecture, engineering, and technical design	476,67	496,67	646,67	827,67	865,67	157,73	152,07	193,01	172,28	169,42
73	731	Commercial space and time services	412	421	522,33	632,67	602	138,26	112,78	165,88	140,14	127,19
74	741	Industrial design					612,33					204,33
77	771	Car rental services	24,33					78,53				
77	772	Consumer goods rental			57,33	51,33				147,96	155,8	
78	781	Employee mediation		106,67					137,36			
78	782	Unemployment agency		167	199,23				168,36	134,64		
82	821	Administrative and secretarial services			94	98,67	94,67			186,54	106,63	107,38
82	823	Organization of congresses etc.		11,67	14		21,33		230,33	91,94		205,59
94	942	Labour unions	8	7,33				0	0			

Attachment 7 – Details on entrepreneurship in related sectors.

SBI02	SBI03		Total amount of enterprises in year aggregate 2001-2003	2004-2006	2007-2009	2010-2012	2013-2015	Startup-rates compared to mean in year aggregate 2001-2003	2004-2006	2007-2009	2010-2012	2013-2015
17	172	Production of paper- and cardboard products				5,33					292,11	
26	261	Production of electronic components	13,33					278,6				
26	262	Production of computers and accesories			7,67					211,74		
26	263	Production of communication devices			3,33	4				262,97	300	
26	264	Production of consumer electronics		7,33	7,67	10,67			253,57	71,3	319,59	
26	265	Production of measurement devices	11,33	10,33	10,33	12,67	10,33	365,74	193,19	338,54	228,94	131,43
26	266	Production of radiation and electro-therapeutic devices				1,33	3,67				196,12	78,42
26	267	Production of optic instruments and devices		4,67	3,33	2,33			189,04	79,4	111	
27	274	Production of electic lights					9,33					262,48
27	279	Production of other electric devices					4,33					500
28	281	Production of water craft components			5,67					91,15		
28	282	Production of other machinery for general use			27,33					274,1		
29	291	Production of cars	2,33	3,33				300	200			
29	292	Production of trailers and semi-trailers	3			1		174,48			0	
29	293	Production of car parts and accesories				3,33					242,79	
41	412	Land development enterprises	282	324,67	484,67			145,22	138,37	124,33		
46	461	Trade mediation	112	137	171			156,4	120,14	146,57		
46	462	Wholesale of livestock and farmequipment	25,67	22,33	20,33			153	93,24	76,26		
46	463	Wholesale of food products	110,67	107,33	106			114,35	115,02	104,63		
46	464	Wholesale of non-food products	311,33	295,67	327			141,2	140,9	124,32		
46	466	Wholesale of machinery and devices for industry and trade	135,33	135,33	133,33			141,78	147,64	123,26		
46	467	Other specialised wholesale	135,67	134	139,33			141,02	117,62	108,2		
46	469	Non-specialised wholesale	23,33	27,67	41,67			64,37	85,86	105,02		
49	491	Public transportation via Train		5	6	6	5		398,16	0	0	0
49	494	Transport of products via road		58,33	69,33	66,67	72,33		93,41	158,52	115,14	98,18
64	641	Monetary financial institutions	41	37,33				315,2	167,63			
64	642	Financial holdings	36,33	17,67				62,82	65,16			
66	661	Financial advisory services			74,67					161,47		
66	662	Insurance services		138		120	101,67		160,07		130,41	144,89
68	682	Real estate rental	88,33	75,33	74,67	71,33		322,31	198,98	163,23	124,89	
68	683	Real estate mediation	126,67	142,67	162,33	158		146,47	152,08	132,71	121,13	
71	712	Examination and control			10	10,67				110,89	141,36	
73	732	Market and opinion polling institutions	71,33	79,33	132,33	138,33	129,67	157,47	140,28	164,09	103,13	139,98
74	742	Photographie and film development					242,33					114,11
74	743	Translation and interpreting					95,33					153,61
74	749	Other specialised services					212					
77	771	Car rental services			18	18				50,66	62,25	
77	772	Consumer goods rental	61,67					105,66				
77	773	Rental of machinery and other products	20,33		31,33	33,33		93,81		179,52	139,79	
78	781	Employee mediation			112					107,63		
82	821	Administrative and secretarial services		73					113,38			
82	822	Call centers		6,67	8,67	9,67	11		112,39	112,45	211,47	165,69
82	829	Other services		20,67	19,67	30	40,67		80,58	69,6	121,32	134,2
94	941	Employer organizations		7,67	7,67	6,33			106,26	295,07	127,84	
94	949	Communal and political organizations		40	38,33		31		112,2	91,86		80,95