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Does history matter?

The case-study of the spatial evolution of computer programming in the Netherlands

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Preface

This Master's Thesis has been completed and it is now in your hands. The end of my Thesis also denotes the completion of my studies for the Master's Program in Economic Geography: Regional Competitiveness and Trade.

This year has been a great lesson to me. Living and studying abroad was a big challenge. The program was highly demanding, but also inspirational at the same time. The combination of Spatial sciences with economics gave me a holistic image about the field of Economic Geography and helped me develop academically and professionally.

However, I would not have finished this project without the help of certain people. So, I would like to thank them for their support and contribution. Firstly, I would like to thank my research supervisor dr. Sierdjan Koster for his guidance and valuable contribution to this Thesis. He was always willing to answer all my questions and discuss all my thoughts. His methodicality helped me delve into the process of research, and explore different academic methods and approaches. I would also like to thank all my professors both from the faculty of Spatial Sciences and from the faculty of Economics and Business. Every course was important in order to have a spherical image about the field and inspired me to take decisions for my Master's Thesis. But also, I feel that they affected a part of my personality and of my way of thinking about what economic geographers aim for, which is the most valuable lesson for my future.

Last but not least, I would like to thank my family and my friends who supported me through this journey.

The best is yet to come!

Eliza Savvopoulou

Abstract

The existing literature gives insights about the emergence of innovation and new entrepreneurial activity, that is concentrated in specific urban locations. Both incidents seem to re-inforce themselves in the same regions, creating a vicious circle of entrepreneurship and regional development. But what is happening with the computer programming industry? Despite the fact that coding combines both innovativeness and entrepreneurship, it presents special characteristics that could counteract the traditional theories about the emergence and spatial evolution of high-tech industries. As such, the theoretical framework analyses the contextual factors that affect the emergence of entrepreneurial activity in the region. Subsequently, an empirical investigation is conducted to explore the spatial evolution of the sector and the underlying mechanisms responsible for the observed patterns. Special attention is given to the role of economic history in contributing to the growth and persistence of the sector in certain regions. Notably, tacit knowledge, which remains challenging to transfer over distances, emerges as a theoretical key driver for future development. A quantitative approach through cartographic and econometric analysis presents the spatial evolution and the main regional causes of the firms and employment growth in the Netherlands from 2000 to 2020. The results show a core-periphery pattern both in terms of firms and of employment, that changes over time. The growth of firms presents an expansive character, where universities, related companies and the short-term changes in the sector matter. On the other hand, jobs remain highly spatially specialized in specific employment centers of large companies and programming hubs, which are shifted in the southern part of the country after 2010. The spatial evolution of a high-tech sector like the computer programming also reveals the spatial inequalities in the country, where the northern part remains underrepresented.

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1. Introduction

1.1. Motivation and background

The second unbundling, with the rise of the Internet, reduced the transportation costs of moving ideas, which resulted in huge changes in the production. Around 1990, when it took place, a new academic thesis about IT causing the end of agglomeration economies had grown (Castells, 1991). The main idea was that as the transportation costs of products (from the first unbundling) and of the ideas had reduced, the centripetal forces of cities would fade away, as the economic agents could maximize their utility anywhere and so geography wouldn't matter anymore (Cairncross, 2001). In the same context and regarding the collaboration among (high-tech) organizations, Boschma, (2005) claims that *"Probably the most important tenet of the proximity school in economic geography is the thesis that geographical proximity between organizations is neither a sufficient nor a necessary condition for learning and interactive innovation to take place".* He believes that these processes are shifting from clustering to the function of knowledge networks, which can be found in different scales (even global) and where other types of proximity (cognitive, social, organizational) play a more important role and eventually they will substitute the geographical proximity in the future. Studies that trying to vindicate this claim, investigate how organizations can collaborate in R&D projects, citations and publications remotely (Balland et al., 2013). The validity of this claim has spatial consequences, as if firms don't need face-to face interactions to transfer knowledge, they won't need to collocate.

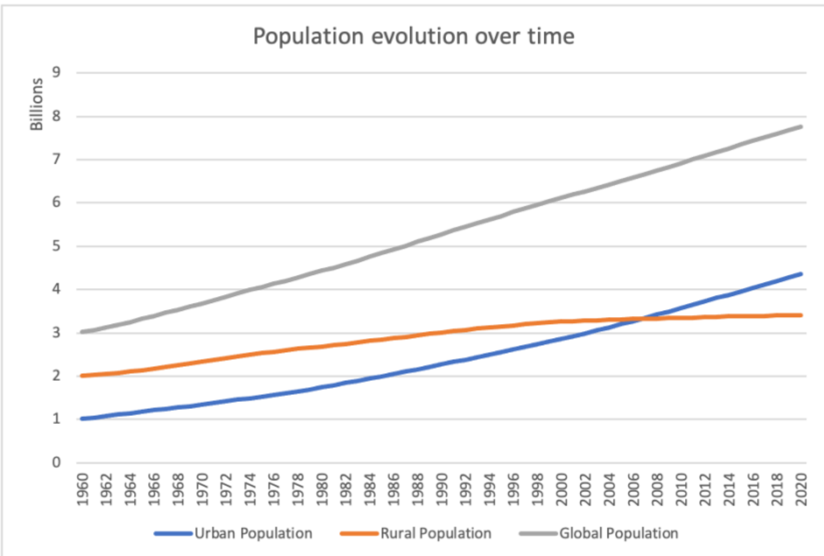


Figure 1.1: Evolution of global population, own work with data from https://ourworldindata.org/urbanization

Nevertheless, the data don't vindicate the theory of the end of agglomerations. Figure 1.1. presents the evolution of total, urban and rural population from 1960 to 2020. From the graph, it is obvious that not only the Internet didn't work as an equalizer of space, as it was expected, but on the contrary, it flattered the functions of cities even more. After the millennium, the urban population experienced rapid growth, while the rural population showed stagnation, indicating the polarization that has taken place. But what is the correlation of this with the distribution of economic activity and the spatial distribution firms? Even though figure 1.1.

doesn't explicitly show the concentration of economic activity in specific places, the concentration of people in cities implies that the economic activity and -most importantly- entrepreneurship is also located there. This is depicted through two schools of thinking in the literature. The first neoclassical school of New Economic Geography considers the number of entrepreneurs as finite. In other words, entrepreneurship is an exogenous factor to the system. However, firms are mobile and affect the regional equilibriums. As such, firms prefer to be located in large cities where they can benefit from home market effects, meaning that they can reach a larger local market but also to trade easier their goods with the neighboring regions (Brakman et al., 2019). On the other hand, entrepreneurship can also appear endogenously in a region. The high population density of cities enables many different people to interact, exchange ideas and thoughts that leads to the emergence of innovation and new entrepreneurial activity. Glaeser, (2010) and Glaeser et al., (1991) discuss about these theoretical approaches of Jacobs and Marshall, where the urban milieu is one of the most important determinants from where entrepreneurial activity turns up organically. So, either the neoclassical perspective or theories of endogenous development support that entrepreneurial activities, which is in the core of economic activity, seem to follow (or to be followed) by residential preferences. Putting it differently, the high concentration of population in cities affects and is affected by the allocation of economic activity in space.

The question is whether the previous argument is also validated for the programming industry in the Netherlands, where the coding has changed some of the traditional narratives of the way that people think and work. Boschma's thesis challenges the conventional belief that spatial proximity is both necessary and sufficient for fostering innovative activity. Even though the recent literature proves that this new revolution of spreading of economic activity affected mostly the location of standardized tasks and jobs, high-tech industries (such as coding) still tend to cluster in cities and benefit from the Marshalian externalities (Sternberg & Litzenberger, 2004). However, as it was aforementioned, the industry of interest presents particular characteristics that could strengthen the dispersion argument. More specifically, the ICT and especially the programming industry is a special industry for three reasons. The first one is that with the rise of remote jobs especially in the programming sector, can attract workforce from all over the globe. Consequently, it could offset the one of the three Marshallian externalities about the labor pooling in agglomeration economies. The second one is the way of communication. As we know, tacit knowledge can't be transferred explicitly through the conventional languages. Nevertheless, the subject of the industry is the creation of another "alternative" language. In fact, we can't be sure what type of information and knowledge can be transferred through distance with the use of this new language. This second element could also counterbalance a second Marshallian externality for "learning" in the agglomeration economy and causing the dispersion of the industry within a region, in a country or even globally. The third and last reason is that the programming industry is a "weightless" industry. The goods and services are transferred through the internet, so the transportation costs don't matter (Quah, 2001). Following the New economic geography theory (McCann, 2013), this can have enormous implications in the firm location in the micro level and the spatial distribution of the industry in the macro level. So, it raises an intriguing question: Does the computer programming industry in the Dutch market align with the spreading perspective? Let's investigate this inquiry and examine whether spatial proximity plays a crucial role in driving innovation within this industry. How is this translated in the spatial evolution of the time? What is the correlation of employment and entrepreneurship in the sector?

The empirical evidence in literature shows exactly the opposite of spreading. The ICT industry tends to cluster to a high degree. And mostly in highly urbanized regions (Castells, 1991; Moriset, 2003). An immense amount of literature proves that the ICT sector is concentrated in specific places both in Europe (see Belitski & Desai, 2016; Koski et al., 2002) and the US(see

Blanc, 2004). Some studies have gone to the next step trying to find the causes behind this pattern of concentration (see Lasagni & Sforzi, 2007; Marinkovic et al., 2018; Turečková, 2018; van Oort & Atzema, 2004) or design policies in order to foster the creation and productivity of ICT clusters (see Grondeau, 2007; Winden et al., 2004). At great help for this project would be a third type of literature which relates the geographical proximity of the ICT firms with innovation (see Frank & Maurseth, 2005; Narula & Santangelo, 2009), as the high concentration of innovative activity in specific places could explain the persistence of programming agglomerations in the Netherlands over time.
All these studies prove that the rise of the internet couldn't substitute the agglomeration externalities and firms and especially high-tech firms tend to cluster in the cities and continue to benefit from agglomeration economies. The question here is whether this is also happening in the Dutch national level and for such a specific sector like computer progeramming. The next and main step for this thesis is to see whether there are agglomerations that remain persistent over time and which are the underlying mechanisms that cause this persistence.

1.2. Research questions

So, this Thesis examines the spatial evolution of the computer programming industry in the Netherlands, from 2000 to 2020, focusing on the role of entrepreneurship. Entrepreneurship is highlighted as it is expected to be the main determinant of economic activity. Entrepreneurs are in the heart of economy, and more precisely of the allocation of economic activity. They are humans who make economic choices that affect the way we live and work. Sometimes, these choices have also spatial dimensions, like the decision of where to start their new company! Even though human capital in terms of specialized workforce could also be a good approach for the allocation of the sector over time, the rational is that every region needs "entrepreneurial human capital" in order to make good use of the existing human capital resources. So, this projects investigates the spatial patterns of distribution of firms and employment of the sector over time. It also investigates the underlying sources of these patterns. So, the main research question that emerges for the distribution of the sector is:

What is the spatial evolution of the programming industry in the Netherlands during 2000-2020?

In order to better understand the patterns of spatial evolution, different schools of economic geography have been analyzed theoretically and been adopted to the empirical part. These three broader aspects describe the factors that favor the emergence of new entrepreneurial activity in a region. More analytically the three broader aspects adopted are the evolutionary school of economic geography, the institutional argument and the role of socio-spatial characteristics for the rise of the phenomenon. Following the literature's discussions, the role of universities and agglomeration economies have been chosen as the most important elements. Universities represent the importance of institutions for the education of human capital and their innovative activities. Additionally they support new entrepreneurs, as most of the times they also work as incubators for new ideas. Agglomeration economies, depict the jacobian argument about the role of cities about innovation and entrepreneurship. Cities are "innovation machines", where people get inspired from the heterogeneity of the urban landscape, have access to funding, human capital and good infrastructure (Florida et al., 2017). As a result, three explanatory questions emerge:

1. *What is the role of path-dependence?*
2. *What is the contribution of universities?*
3. *What is the role of agglomeration economies?*

The main focus has been given in the role of path-dependence, which is in the core of the evolutionary economic geography thesis. So, the main idea here is that the existence of firms in the same sector creates a more favorable context for the future firms to get settled in the same region. The reasoning of concentrating in this theoretical field more than the others, entails two main arguments. The first one is that as this project has a dynamic character (it involves time dimensions), the evolutionary approach seems to be the more appropriate approach as it is based on historic economic conditions. The second one is that many aspects of this school of economic geography are industry-oriented and not general for entrepreneurial activity in a region. As the subject of the thesis is about the spatial evolution of a specific industry, it is suitable to follow this path. However, the other two arguments are not forgotten. The contribution of universities in the second explanatory question refers to the role of institutions in the regional new firm formation, while the role of agglomeration economies is probably the strongest spatial characteristic when we are talking about entrepreneurship in a region.

1.3. Approach

In order to observe and comprehend the spatial evolution of the programming, we follow thew spatial patterns of the industry over time. To achieve that, a purely quantitative approach has been adopted. Data regarding the business demography of the sector and some other spatial and structural aspects of the local economy have been used.

In order to explain the spatial patterns of evolution and the spatial unevenness in economic activity, the concepts of the creation of new firms and entrepreneurship are analysed. Putting differently new entrepreneurial activity in a region is considered as the main channel through industrial clusters are born and possibly remain persistent over time. The theoretical part is based on that mentality. Although a characteristic structure for this type of studies is the analysis of the elements through the channels of regional supply and demand like Verheul et al., (2001) used, this project makes a different classification. As the main subject of investigation is the spatial distribution of an industry, the theoretical part focuses more in the regional point of view rather than the economic. It does that, by explaining how different economic mechanisms are embedded in the region, and as a result, how these different aspects of the region can determine the creation of the new firms. As it was previously mentioned, it recognizes three main theses about how the region itself can affect the economic paths it will follow. Path-dependence is the first thesis, where economic history is considered the most important contributor to the new firm formation, as the existing industrial landscape will determine the (sectoral) nature and performance of the new firms. The second claims that holistic regional economic planning, through the establishment of regional innovation systems, the foundation of intermediate, sectoral specific institutions and the fostering of specific sectors can create new economic paths for the region. Socio-spatial determinants are not forgotten. Stable, slowly changing characteristics of each region is a part of its uniqueness and determines its economic performance. Economic actors like households and firms are more immobile than the neoclassical economic school thinks, so the composition of regional society is one of the "sticky" spatial elements. Infrastructure and natural geography also characterize the region.

The whole project implies the high-tech nature and the innovative capacity of the programming industry. To be more specific, it focuses on knowledge spillovers and innovation as the underlying mechanisms and spin-off companies as an intermediate outcome causing the growth of the sector in persistent hubs over time. So, each of the three components (path-dependence, regional policies and socio-spatial characteristics), will be analyzed, highlighting their contribution to the previous mechanisms.

So, the second chapter of the project analyzes all the pre-mentioned theoretical mechanisms that affect the emergence of entrepreneurial activity in a region. It ends with the design of the conceptual model. The third chapter explains the adopted methodology. More analytically, two main approaches have been followed. The first approach can be characterized as the cartographic approach, which employs 5-year interval maps to visually illustrate the spatial evolution of firms and employment. These maps serve as clear evidence of how the distribution of businesses and job opportunities has changed over time. The second one is the econometric approach, which investigates the sources of the spatial evolution in terms of the existence and persistence of hubs, of the growth of firms and employment in the sector. The spatial scale of reference is the municipal, while there are annual time dimensions for a selected period of 21 years (from 2000 to 2020). The fourth chapter presents and analyses the cartographic and the econometric results while the fifth and last chapter concludes and puts some personal thoughts about the future.

2. Theoretical framework

2.1. Path-dependence

Persistence and path-dependence co-exist and can affect each other but they are not identical. The question here is at which degree the first is a result of the latter for the programming industry in the Netherlands. Even though these two phenomena are different, the fact that they are both visible only across time can make their distinction a little blunt.
Persistence is a statistical process which indicates that a phenomenon remains steady over time. On the other hand, path-dependence is more associated with the effect of (economic) historic events on the current situation. Adopting the expression of Martin and Sunley (2006), *"landscape inherits its legacy of its own past industrial and institutional development"*. It explains how similar economic activities in a region in the past create favorable conditions for the same/ or similar activities to take place in the same region in the future (Andersson & Koster, 2011). Nevertheless, the beginning of the story, meaning the location decision of the first firm, which the others follow, still remains unclear. Evolutionary economic geographers claim that this selection was made by chance. Path-dependence usually takes place in the local or regional levels, as the underlying mechanisms of the phenomenon are embedded in the specific cities and regions. Also, the level of their operation is local, with a difficulty in spreading across space. In other words, space plays a very important role for path dependence to emerge. The regional economic space has a double role as it can both be affected from, and affect the decisions made but the economic agents (individuals, firms, other organisations etc.) (Martin & Sunley, 2006). The structure and conditions of the regional economy have an effect in decisions and action of agents, while at the same time these actions and decisions shape the whole regional economy that may affect new decisions in the future. But which are those underlying mechanisms causing path-dependence? According to the literature, path-dependence happens due to Increasing returns of scale and the institutional hysteresis in a place (Andersson & Koster, 2011).

2.1.1. Increasing returns of scale

2.1.1.1. Marshallian externalities

Increasing returns to scale refer to the industrial composition and the "technological regime" of the place and how these historical elements can determine the future ones. Even from 1920 Marshall observed that the spatial distribution of many industries was highly concentrated, indicating that firms from the same industry benefit from collocation. In fact, he claimed, that the sectoral specialization of the region, also known as localization economies, is lucrative both for firms and for the region itself, as it creates an environment where the sectoral knowledge is diffused. He concluded that the agglomeration of firms in the same sector creates positive externalities in the region, while the firms are both provokers and benefactors of these externalities. In modern literature these effects can be found as "sharing, matching, learning" implying three different types of externalities contributing to Marshallian localization economies (Duranton & Puga, 2001). Beginning from the last one, "learning" is used in order to explain the previous process of knowledge spillovers in a cluster. The expression "there is something in the air" implicits that this knowledge is highly localized and can't be transferred through distance. In other words, tacit knowledge is created, which according to the literature is spread only through social interaction, and that is the reason the spatial proximity of the firms is of highly importance. According to Marshall, knowledge can be spread and used in a productive, innovative way only among firms in the same industry, as all the others (e.g. firms) are not familiar with the nature of the sector and as a result they don't know how to use this new knowledge. In these clusters the agents don't compete with each other, but on the contrary, they collaborate, so involuntarily knowledge diffusion doesn't take place.

The term of "sharing" refers to infrastructure or different kind of services, which the firms in cluster share and results in decreasing costs. As it is logical, where more firms and economic activity exists (and consequently more households), usually there are bigger and high-quality infrastructure (e.g. roads, telecommunications etc) but also related services (e.g. legal services) as there are more users, and so it is more efficient to be developed there. This creates a high demand market but also a well-connected and accessible market for new firms to be born and get settled there.

Regarding the "pooling" term, it refers to the pooling of a specialized workforce. Following the neoclassical model of supply and demand, more firms in a sector being in the same region, the more is the demand for labor in this sector which results in immigration of specialized people in that region (McCann, 2013). Existing and future firms benefit from this pooling as they can fill their vacancies quickly with high-quality workers, while at the same time they don't have to train them, which reduces their costs . So, according to Marshall, localization economies is the most efficient spatial form of industrial composition in terms of regional growth and firms. All these three externalities contribute significantly to path dependence as they create favorable conditions (providing knowledge, accessibility to high infrastructure and specialized workforce) in order new firms to be created either endogenously from the system itself or to attract firms from other regions(Cainelli & Ganau, 2021).

2.1.1.2. The role of related industries

There's been relatively recent growing literature about the role of related industries and their contribution to path-dependence. It is based on the Jacobian argument for urbanization economies, where the diversity in firms (and people) create higher levels of innovation. Following Schumpeter's theory about innovation coming from new combinations of production factors, Jacobs claims that the more the different types of firms in the same region, the more the combinations and as a result the more the innovation emerging locally (Cainelli & Ganau, 2021; Jacobs, 1969). However, the argument of relatedness narrowed the notion of diversity in industries that are actually related to the industry of interest, either through trading or by sharing common technology (Hidalgo et al., 2018). Many studies showed how related industries affected the emergence of a technology, industry, product, occupation and sector in a region (Hidalgo et al., 2018). Neffke & Henning, (2013), investigating from a human capital perspective in the case of Sweden, add a third dimension in relatedness (except from technology and trade), which is skill relatedness, as firms that need the same skills can share the same workforce. In this case, people through their skills constitute the connection among different sectors. Neffke et al., (2011), following an evolutionary approach, found that also the related industries are a solid source of creating new regional economic paths in Sweden, which are in accordance with the results of Zhu et al., (2017) for China. The pitfall is that agglomeration economies have an advantage while other rural peripheral regions face a difficulty in creating new paths, which results in regional inequalities to be produced and reinforced through path-dependence. (Hidalgo et al., 2018).

2.1.1.3. Spin-off processes

Until now, the two previously analyzed theses supported that the outcome of clusters is a result of spatial externalities. Places and regions have the main role here, while all the processes are external to the firms. Shifting to a managerial point of view, localization economies are an outcome originated from processes internal to firms. In other words, according to this theory, space and places don't have such an active role as in the previous theories but a more passive

one. Regions serve as receivers of firms' functions, which have a spatial impact translated into clusters.
The whole discussion here is about the founders of new firms and more especially where they got their experience and how this affects their decisions about the location of the new firms. Following Buenstorf & Klepper (2010) categorization of new firms based on the founder's previous experience, entries could be diversifiers, spin-offs or start-ups. Diversifiers are new firms in an industry, originated by a different related industry, meaning that the entrepreneur used to work for a related industry before. Except for the decisions about location the previous experience of the employer determines the success of the new firm, too (Klepper, 2010). For a diversifier firm to be successful, the parent company must be successful, too. Even though this is a prerequisite, it is not a sufficient condition. Klepper (2010) claims that the more related the previous industry with the new one, the bigger the probability for success for the new firm. Spin-offs are new companies where the founders used to work for the same industry before. The same condition as for diversifiers is valid here, too. The more successful the parent firm the more successful the spin-off company will be. As this is not enough, the ability of transfer of knowledge from the parent firm to the new firm will determine the performance of the spin-offs.
The third and last category is the start-ups where the entrepreneur has no related knowledge to the sector. The first two categories could easily be related with the two previous agglomeration theories about the evolutionary creation of clusters, by relating spin-offs with the Marshallian externalities and localization economies and diversifiers with the role of related industries.
A big body of literature is devoted to spin-offs and their performance. It seems that this category presents the best performance as new firms (R. A. Boschma & Weterings, 2005; Buenstorf & Klepper, 2010; Klepper, 2007, 2010; Koster, 2004; Wenting, 2008; Weterings & Koster, 2007). Even though the literature analyzes in depth the spatial outcome derived from the creation of spin-offs, there is a gap about the reasons behind the birth of a spin-off company, meaning the process of an employee leaving a company in order to start another one on her/his own. Klepper & Thompson (2007), fill this gap, arguing that the birth of a spin-off is a result of disagreements. To be more specific, according to them a firm has different decision makers. All of them receive different information (also known as "signals"). Based on this information, each of them has a different opinion about the path the firm should take. When all decision makers agree that all the information has the same validity, then they agree on a common path. Nevertheless, if a decision maker evaluates her/his sources higher than the rest, then a disagreement will arise. In this case, if the specific person can exploit the knowledge in an effective way, and if it exceeds the costs of opening a new firm, then the employee will leave and start a new one of her/his own. As a consequence, the new plant benefits from the old company, as the entrepreneur transfers the knowledge and routines which uses as inputs in the new company. The spin-off has some overlap with the parent company as it inherits elements, however it is not identical, as it also pursuits new ideas that the parent company refused to (Klepper, 2007).
But how does this affect the spatial distribution of the industry? Spin-offs prefer settling in the same regions as their parents are, as they can benefit from the proximity (Klepper & Thompson, 2006; Wenting, 2008; Weterings & Koster, 2007). That happens due to the fact that founders of spin-offs have better knowledge for the local market and also have already developed interpersonal networks, that are beneficial for the new firm (Weterings & Koster, 2007).
There are many case-studies for the role of the spin-off companies in the creation of clusters in specific regions with the most characteristic being the semiconductor industry in Silicon Valley (Klepper, 2010), the automobile industry in Detroit (Klepper, 2007), the tire industry in Ohio (Buenstorf & Klepper, 2010), the laser industry (Klepper & Sleeper, 2005), the disk industry

(Franco & Filson, 2006). Nevertheless, apart from manufacturing, the same processes are valid for other creative and innovative sectors, too, such as the fashion industry, where the diffusion of spin-offs contributed to the persistence of specific cities such as Paris and Milano being in top fashion cities for over a century (Wenting, 2008). The last example is extremely insightful for the purpose of this project, as the software/programming industry's nature is closer to the fashion sector, which is more creative, innovative and service-oriented rather than production-oriented.

Until now two main opinions have been analyzed. On the one hand, economic geographers suggest that agglomeration externalities make the firms in a region more efficient, while in the same time this attracts new firms in the region. On the other hand, evolutionary economists claim that this process is internal to the regional firms. Big successful firms spun new firms in the region where they're in. The outcome of this process is the creation of clusters, which are particularly stable as successful spin-offs will create a new generation of spin-offs in the future. What has been described above is an issue of reverse causality. Agglomeration economies benefit the firms or the companies create agglomeration economies? Boschma & Frenken, (2003) argue that the two opinions are not mutually exclusive. On the contrary, they enforce each other. While spin-off companies may shape agglomeration economies and create all these beneficial externalities, at the same time localization economies with their externalities create a favorable environment for new spin-offs to be born.

2.1.2.Institutional Hysteresis

The creation of firms is the benchmark of this analysis as it's the main channel through which path-dependence can take place. As a result, entrepreneurship could not miss from the discussion. Different levels of entrepreneurship among regions influence the growth of firms in the region in a direct way. The previously analyzed dimensions of economic path-dependence were industry-specific, which means that the mechanisms work for the sector of interest and related industries. However, entrepreneurship can affect the whole local economy. Even if there are knowledge and economic opportunities in the region, if the "inclination for entrepreneurship is low" the most possible scenario is that most of the opportunities will remain unexploited. Institutional hysteresis fills that gap in the literature. Institutional hysteresis is about all the informal and formal institutions affecting and being affected by the local economic behavior (Andersson & Koster, 2011). Formal institutions are referred to all rules and regulations which compose the legal framework in a region. Informal institutions are more about local perceptions and values. The combination of them determines the function of the local society, determining the decisions that economic actors will make, but at the same time, it is shaped by these decisions (Setterfield, 1993). In order to understand better how institutional works, the process of starting an entrepreneurial activity by Shane, (2001) is followed. This process has three "requirements". The first one is about existing entrepreneurial opportunities in the market. This is exogenous from the individual himself and it is mostly based on the regional economic structure. According to Schumpeter, innovations are not increasing linearly, but one innovation/invention can bore multiple innovations in a region/market (Andersson & Koster, 2011). The second is about the ability of people to recognize the opportunity, while the third refers to the willingness of the individual to take on a firm after recognizing the opportunity. The two first reasons are closely correlated with Increasing economies of scale, created through knowledge spillovers and the pooling of highly skilled workforce, which is able to recognize the gaps in the market. The third one is related to institutional hysteresis, as the decision of the individual to start a company is influenced by things such as access to finance, the regulation of the market (how easy the entry and exit), local values, and beliefs about entrepreneurship. There are lots of studies investigating these factors. For example, Davidsson & Wiklund, (1997) taking into account 80 Regional labor markets in Sweden and following a quantitative approach, found that local values and beliefs had an effect on regional new firm formation. Gherhes et al., (2018), showed that local values and beliefs impede new firm formation in peripheral places in the UK, that fell behind after the de-industrialization era.

2.2. The policy aspect

However, history is not the only contributor to the creation of new firms in a region. Regional, place-based policies can also stimulate entrepreneurial activity. There are multiple ways in order to achieve this goal. Even though there is not a "one size fits all" strategy, which the institutional and spatial differences should be taken into account before implementing regional economic policies, some common patterns of initiatives have been distinguished (Minniti, 2008). A quite strong thesis about policy aiming for regional development supports big investments in infrastructure. Following Florida's idea about the "creative class", human capital is quite mobile. Jobs, innovations, and new firms follow people where they live and not the other way around. Having that in mind, investing in amenities and infrastructure seems a rational idea, as it can attract and retain all the creative people (like entrepreneurs) in the region (Pike et al., 2016). Education and training of people can also play an important role in the creation and performance of new firms. Regional policy investing in education and training programs, helps entrepreneurs develop the skills and knowledge they need to start and succeed. In addition, rules and regulations are significant determinants for people to start a firm. Deregulation of specific markets (like lowering the entry barriers) and access to finance enhance entrepreneurial activities (Minniti, 2008).

2.2.1. Cluster policy and Regional Innovation systems

Although the previous local strategies can stimulate entrepreneurship in a particular region, regional policies can be even more specific and foster individual sectors through cluster policies. Differently, regional policies can create new paths for the region in interest by favoring and promoting single sectors. The foundation of sector-specific institutions (like promoting offices) could be an intermediate output of this policy (Champenois, 2012). According to Champenois, (2012), cluster policy fosters regional new firm formation through 3 mechanisms. Firstly, it converges the interests of economic actors (firms in this case) in the region, which leads to collective action for local sustaining entrepreneurship. Second, it formalizes collaboration among local firms. This function not only enables the existing collaborations but also enhances future ones as it makes it easier and solves the problem of misinformation among actors. Thirdly, the new sector-specific institutions work as mediators among employers and employees, help in better matching, and also support and inform future entrepreneurs. Having a supportive institution can be very encouraging for new entrepreneurs to start a business. Nevertheless, there is also quite a criticism of this policy. A known opposition to the policy is its effectiveness on the macro-scale or just being a zero-sum game. As cluster policies often extract economic activity from other regions in the country (by giving financial and other incentives), it could be doubtful how it can really increase the national output (Duranton, 2011). The results from empirics also differ, with some finding positive and significant results (Champenois, 2012) while others claim that it affects only partly the output (Audretsch et al., 2016).

In the modern global economy, competitiveness seems to have become even more important for regions to thrive. As knowledge-based activities and innovation are the most popular contributors in order to create a competitive advantage in this market, more and more policymakers adopt a Regional Innovation System (RIS) approach (Asheim et al., 2011). There is not a specific RIS definition in the literature but the main idea is "*a set of interacting private and public interests, formal institutions and other organizations that function according to organizational and institutional arrangements and relationships conducive to the generation, use and dissemination of knowledge*" (Doloreux & Parto, 2004). Someone would claim that regional innovation systems are a broader form of cluster policy as they are not restricted only to specific factors but they give more emphasis on high-tech, knowledge-based activities. Nevertheless, this approach differs from Porter's cluster approach in two ways. Firstly, it can reveal the operation of an interactive system leading to knowledge. Secondly, even though Porter recognized the importance of the existence of institutions in the cluster model, they had a more passive role in the whole process of interaction. In contrast, RIS put the institutions at the heart of the system, as they are the coordinators of the system while at the same time, they are active contributors by creating knowledge and enhancing interaction for the other two parts (firms and society) (Asheim et al., 2011).

2.2.2. The role of university

Today the role of the university is of primary importance for regional development and entrepreneurship. Historically speaking, the university wasn't always linked with these issues. Until the First World War universities had very limited interaction with the local society and economy, as only very rich people used to be highly educated while the subjects of the research weren't easily applicable in real life (Goddard & Puukka, 2008). Public funding supported universities until 1960, which also allowed the universities to be autonomous and pursue other goals, unrelated to the regions they were settled in (Harloe & Perry, 2004). After 1970, when the Keynesian macroeconomic models were rejected, things started to change. With the second unbundling in 1990 when the trade costs decreased dramatically, lots of developing countries extracted industrial economic activities from the developed ones, as they could offer cheaper production factors. This new global economy intensified the urgency of innovation for development. As innovation takes place mostly on a local scale, regions have become the engines of regional development while universities are the engines of innovation and knowledge (Drabenstott, 2008). Regional policies try to bring both of them together to collaborate in order to create a comparative advantage in this global market (Douglas, 2008). In the modern knowledge-based economy, the university is at the heart of the system. In contrast with the traditional university, the modern university seems to be more engaged with the territories where it is in and create knowledge that can be beneficial for the local economy and society. Also, it has a new way of producing knowledge, as this knowledge interacts and often is reinforced by other local institutions, enhancing a systemic approach to learning and creating (Trippl et al., 2015). Today the university has three main functions: (1) to educate people, (2) to conduct research and (3) to exploit the new knowledge it creates through university spin-offs, patents, and licenses. All three functions affect the performance of local existing firms and the creation of new ones either directly or indirectly.

Through its primary function of educating people, the university educates the local workforce. It develops the human capital in the region which is the most important factor for innovation and development. Apart from the local people, it can also attract foreign talents that will create a new stock of knowledge and possibly stay and work in the region (Trippl et al., 2015). University seems to "cultivate" Florida's creative class for the region either providing high-skilled employees for local firms or nurturing new entrepreneurs. This is closely linked with the second requirement for starting a new firm that was previously mentioned by Shane (2001), which was about the recognition of entrepreneurial opportunities in the market. High-skilled and trained people are more likely to recognize these opportunities. So, the university works as a "supplier" of human capital and future entrepreneurs for the region.

The restriction of public funding forced the university to engage more in applicable and beneficial territory research. In order to survive, it becomes more collaborative with the regional community and economy, through formal and informal interactions. Formal contracts with local firms providing industrial research are one example (Trippl et al., 2015). As a result, the knowledge spillovers among institutions, the university, and firms help the local economy and firms to innovate and have better performance in comparison with other firms in places without proximity to a research university. In addition, a highly-ranked university could work as a place branding for the region, attracting investment and firms in the private sector (Goddard & Puukka, 2008). This second function is related to Shane's first step about the existence of entrepreneurial opportunities in the market, as the university creates these opportunities.

However, it can also exploit this knowledge economically. The third function of the modern entrepreneurial university is complementary to the two traditional ones (educating and conducting research) (Gübeli & Doloreux, 2005) and it directly affects the regional new firm formation through university spin-off companies. Similarly, to corporate spin-offs, university spin-offs (USOs) are companies whose founders come from another (the parent) organization, this time being the university. According to Gübeli & Doloreux, (2005) USOs present the following characteristics: (1) its founders come from the university, (2) the original idea got born in the university, during the academic/professional life of the founders and (3) there is a transfer of technology (even bigger than in corporate spin-offs) from the university to the new company. Nevertheless not all research universities present the same intensity in the creation of spin-offs. It seems that the involvement of the R&D activities and an entrepreneurial climate affect this process positively. Of course, similarly to the case of corporate spin-offs, this process has a spatial impact, as the USOs prefer to locate in proximity to the university as they can benefit from its creation of new knowledge and use its network (clients, investors, etc.) (Gübeli & Doloreux, 2005). There are many examples, where specialized clusters of firms were developed close to a big research university. Three characteristic examples in the US are: Silicon Valley, Boston, and the Austin area in Texas (Douglas, 2008).

Concluding, the modern university has multiple functions which are closely related to regional development and more specifically to the performance of existing regional firms and new firm formation. However, not all the previous characteristics and mechanisms apply to each university as its function also depends on the spatial context, meaning the local institutions, values, and economic and industrial landscape (Gübeli & Doloreux, 2005).

2.3. Other spatial characteristics

A last third broader category affecting entrepreneurial activity in a region is about specific spatial characteristics. A great body of literature has been devoted to recognizing and analyzing the different dimensions of the regional context in which entrepreneurship takes place (Johansson & Wigren, 1996; Sternberg, 2009; Verheul et al., 2001). Adopting the expression of Andersson & Koster, (2011), it includes all the “sticky spatial characteristics” of a region. They are characteristics that change very slowly across time like natural geography, the socioeconomic and demographic composition of the population, and regional infrastructure.

2.3.1. Natural geography

Even though natural geography is often neglected in economic geography theory, it plays a crucial role in the economic development of the region. Back when the agricultural sector was dominant in the economy, soil fertility was one of the most significant factors for the distribution of economic activity (Johansson & Wigren, 1996). Today, land fertility is not so important, as the agricultural sector is not governing the global economy, other things like accessibility through land or sea, altitude, etc. affect population density and consequently regional productivity (Combes et al., 2010).

2.3.2. Socio-economic and demographic composition of the population

In a region, potential entrepreneurs usually come from the local population. As a result, its characteristics can determine the supply of new entrepreneurs and firms in the region. Starting from the demographics, urban density seems to be positively related to start-up rates (Wagner & Sternberg, 2004). The spatial proximity with lots of other people and firms enhances social interactions which often lead to knowledge spillovers and innovation. As a result, in a dense environment, there are multiple entrepreneurial opportunities. For the age on the other hand, the results are quite contradicting. While many studies find that a large share of the middle-aged population is a positive fact, as people at a certain age is more possible to start a firm (around 40s) (Wagner & Sternberg, 2004), others indicate the nascent entrepreneurship usually occurs between 25 and 34 years old people ((Verheul et al., 2001). The first thesis seems to gain ground in terms of the performance of the new firms, as after a certain age the entrepreneur can benefit from her/his previous experience and networks she/he has already developed (Verheul et al., 2001).

From a social point of view, immigrants contribute significantly to entrepreneurial activities in a region. As they have already left their home region/country they have taken a risk, an element which is pre required for taking on entrepreneurial activities. Many studies have shown that there is a much greater possibility to start a firm than for native residents (Davidsson & Wiklund, 1997). Regarding unemployment, also the results are contradictory, as they are prone to different types of entrepreneurship that are used in empirics. In conclusion, it seems to be positively correlated with entrepreneurship out of necessity, but negatively correlated with opportunity entrepreneurship and innovation (Bosma & Sternberg, 2014). However, the income disparity is a positive thing for new firm formation. That is for two reasons. Firstly, high-income disparity means that there is a large and differentiated market demand for goods and services, which leaves a lot of room for new different firms. Secondly, in such places, two types of entrepreneurship can be observed. The first is the necessity type of self-employment where low-paid people will be engaged as the cost of risk is quite low. The second is the opportunity type of entrepreneurship where highly-paid people will be engaged, as they can cover the high costs of risk (Verheul et al., 2001).

As far as the economic conditions of the population are concerned, the combination of high income and high survival of small firms in the region can be the key to success for new firm formation, as people can afford to start a business, while at the same time, they can start with a low budget, setting up a new small firm (Verheul et al., 2001).

2.3.3. Infrastructure and existing agglomerations

Infrastructures and agglomeration are linked and have a positive influence on the new firm formation. Specifically, agglomeration economies have already developed entrepreneurial networks and institutions the new entrepreneur can benefit from (Johansson & Wigren, 1996). On the other hand, infrastructure also enhances new firm formation in the region. Investments in infrastructure are quite different from capital investments. The cost of investment is very large and not directly returnable, but only through indirect channels like taxation, new firm formation, the attraction of new people, etc. (Audretsch et al., 2015) However, in this case, it’s not the value or the size of infrastructure that matters, but the consequences it has on economic activity (Johansson & Wigren, 1996). So, the firm doesn’t pay for this type of investment, but it benefits from it, as infrastructure amplifies connectivity between people and firms, and intensifies knowledge spillovers. Studies for a new road network in the UK (Gibbons et al., 2019) and the extension of the metro in Madrid (Mejia-Dorantes et al., 2012), showed that transportation infrastructure had a positive effect on regional employment and the number of establishments.

2.4. Conceptual framework

In summary, 3 broad categories that affect the new firm formation have been identified in the theoretical framework: Path-dependence, regional policy and strategies, and other spatial determinants. Path dependence is one of the most important parts of evolutionary geography. The main idea is that economic history, the existing regional industrial landscape, and the "entrepreneurial climate" affect the creation of new opportunities in a specific sector and the decisions of individuals for starting a new business. On the other hand, regional policy and strategies is an academic thesis that claims that designing a regional strategy can be very effective in the new firm formation in a specific sector and can create a new path for the region. Last but not least, there are specific slowly-changing characteristics in each region that also affect the whole process of entrepreneurship. Even though each thesis provides different arguments, this project doesn't preclude any of the categories. In contrast, they are taken into account as complementaries and not as competitors. Figure 2.4 below summarizes and categorizes all the elements analyzed in the theoretical framework, while it also presents the intermediate mechanisms through which the new firm formation happens. All of the three arguments contribute to new firm formation in a region through multiple channels such as infrastructure, human capital etc. However, knowledge spillovers have been highlighted in figure 2.4. The reasoning of that lies to the innovative character of the industry under investigation. As literature suggests, the spread of knowledge is the primary determinant for the development of high-tech industries in the regional level. Knowledge spillovers are originated from interactive innovation systems and HEIs but also from the existing related firms. They can contribute directly to new entrepreneurial activity, as the local knowledge can be exploited from potential entrepreneurs in the region. Additionally, the production and diffusion of knowledge can also be translated into new entrepreneurial activity in a sector through the conduit of spin-off companies. Apart from the diffusion of knowledge in the local market, working relationships can affect the phenomenon of new firm formation. Employees who used to work and produce knowledge in the same or related industries can decide to start their own firm in the same region. Similarly, people who study or work in universities also create inventions that can be translated into corporate ideas, through the form of USOs. The figure below reveals the relationship between knowledge and spin-off companies, through a dotted arrow, which represents the underlying requirement of knowledge for the formation of spin-offs. Also, the shape of spin-off firms adjoins the new firms' formation, as in fact they are included in the number of new firms in the region.

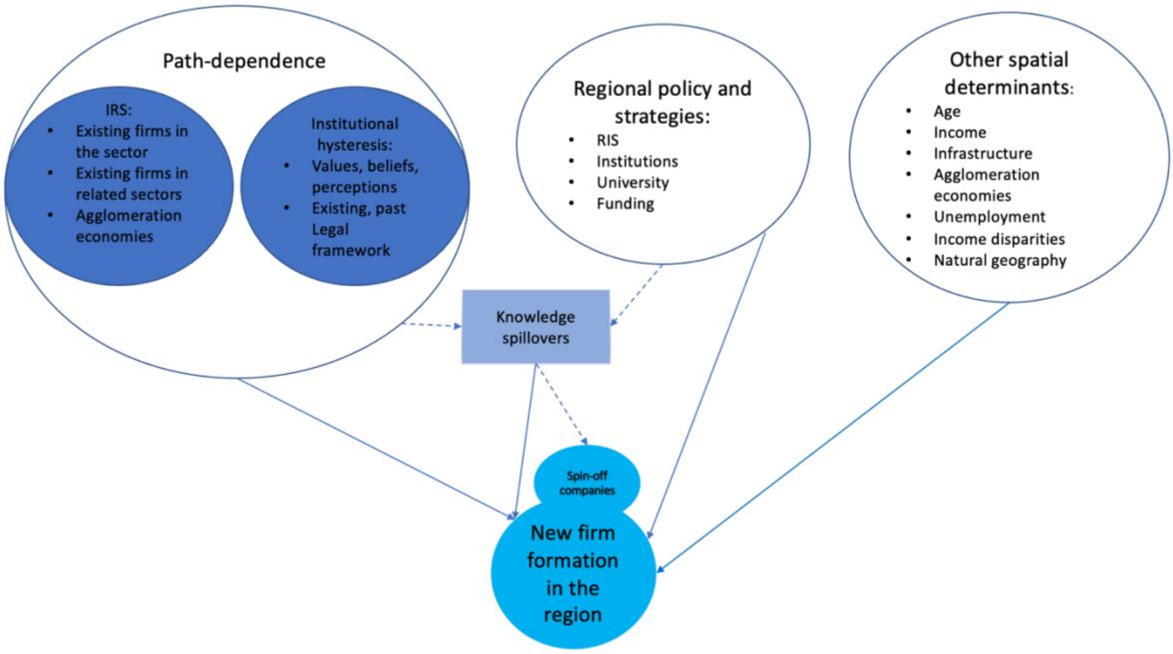


Figure 2.4.: Conceptual Framework. Source: own work

The conceptual framework is directly correlated with the main research question and the three sub-questions under investigation. The spatial evolution of the computer programming industry in the Netherlands is expected to be affected by all the three arguments. Each sub question corresponds to one of the three theoretical schools. Except for path-dependence where the correlation is evident, universities represent the role of regional policies and supportive institutions while agglomeration economies have been selected as one of the most representative elements for the spatial characteristics of a region. Following the literature's suggestion, someone would expect that the high-tech industry of computer programming tends to be and remain concentrated within large densely populated cities, where the advantages of agglomeration economies and the plethora of supportive mechanisms and institutions provide knowledge, funding, high-quality infrastructure and human capital that enhance the growth of entrepreneurial activity and innovation. Furthermore, as we are talking about the evolution of a specific sector, path-dependence is expected to be the one of the most important determinants. In other words, it is expected that the regions which presented an advantage in terms of firms and employment at the beginning of the investigated era, will keep this advantage and grow even more as the time passes.

3. Empirical strategy and data

The aim of the empirical part is to examine the evolution of firms of software companies in the Netherlands, through a quantitative approach. According to the theory, the underlying mechanisms of the emergence of innovative activities take place mostly at the local level. Empirical studies around the emergence of start-up companies (Andersson & Koster, 2011; Hans & Koster, 2018) suggest that the municipal level is the most appropriate. As the computer programming industry is considered as a high-tech innovative sector, the underlying mechanisms of the birth of new firms are expected to be highly localized and hence, the spatial reference unit is the municipality. Since the main subject is to examine the contribution of path-dependence in the spatial evolution of the industry, an extended period of 21 years (from 2000 to 2020) is examined. At this point, it is important to note that the project partially focuses on the geography of municipalities. While there are maps available that provide a comprehensive view of the sector in the country, highlighting the significance of geography, the analysis of potential factors influencing the spatial development of programming appears to align more closely with the school of urban economics. This approach emphasizes in the internal spatial and historical conditions as the main drivers of progress in each location, without considering spatial interactions with the center or neighboring municipalities.

3.1. Empirical strategy

The adopted quantitative method is divided into 2 broader categories: the cartographic method and the econometric method. The use of these two categories, provides a holistic image of the spatial evolution, as there is a transition from the macro-national scale in the cartographic approach, to the micro-local scale in the econometric approach. The combination of the two steps answers the main research question about the spatial evolution of the industry, but also to the three sub-questions and the three sub-questions. The national scale of cartographic approach presents the spatial patterns of computer programming industry in terms of companies and employment during time in the country. On the other hand, the second econometric step in the analysis examines the underlying mechanisms that provoke growth in employment and firms in programming in the municipal scale, taking into account all the three theoretical arguments asked in the sub-questions. Last but not least, the usage of both levels in the empirics makes the intercorrelation of different scales evident, as each municipality is a part of the country, but also the summary of municipalities creates the national spatial image of the industry.

3.1.1. Cartographic approach

Someone could suggest that the cartographic section works also as an introductory result for the econometrics. It mainly consists of maps and diagrams. These maps give insights about the spatial evolution of firms and employment in the computer programming industry in the Netherlands. Relative data for firms categorized by their size, and employment are used. Maps play a crucial role in analyzing the evolution of firms and employment in the sector as they visualize their progress over time for the whole country. Specifically, three distinct groups of maps provide valuable insights. The first group showcases the evolving total number of firms over time. The second group focuses on the evolution of specialization, specifically examining changes in sectoral firms within a municipality , while the third group explores the evolution of employment patterns within the country. To grasp the evolutionary process, a series of maps is created for each group, capturing data for every five-year interval. These maps enhance our understanding of how these aspects evolve and change over time. The groups that focus on specialization patterns use the Location Quotient (LQ) index. This index serves as a metric to gauge the level of concentration of firms and employment within each municipality. It compares the share of firms and employment in the sector of interest in a specific municipality to the overall figures for the entire country, thus providing a benchmark for assessing concentration levels. So, the formula that measures LQ is:

$(f_{s,i}/\Sigma f_i)/(f_s/\Sigma f)$,

where fs,i represents the number of firms in the software industry in municipality i. Σfi denotes the sum of the number of firms in the software industry across all municipalities in the country. fs represents the total number of firms in the software industry in the country. Σf signifies the sum of the number of firms across all sectors in the country. As a result, if the share of the firms in the sector in the municipality i is bigger than its share in the national economy, then the fraction will be bigger than 1, which means that the municipality is specialized in this sector comparatively with the country. If the fraction equals to 1, the municipality represents the national share, while if it's below 1, then the sector is underrepresented in the municipality i.
The same fraction is utilized for employment, with the only difference being that instead of firms, the number of jobs in the sector are measured.

3.1.2. Econometric approach

The econometric approach aims to find the potential contribution of path-dependence in the evolution of the sector in each municipality, taking into account only the internal local conditions. However, the spatial evolution of a sector can have multiple dimensions. In order to grasp a holistic image of this process, three aspects, which also serve as dependent variables in different models, are used. These are: (1) the size of the sector in terms of firms in the municipality i, the growth of (2) firms and (3) employment. Their translation into dependent variables is: (1) the logarithm of total number of firms, (2) annual change in companies in the sector and (3) logarithm of annual change in the number of jobs in the sector.
Following the theoretical part and the conceptual model of this project, representative variables from all of the three broad categories that affect the emergence of entrepreneurship are used in the models as independent variables. The logic for that, is to examine which variables matter for the computer programming sector and at what extent. So, regarding the spatial characteristics of a region, agglomeration economies were chosen. Population density represents agglomeration economies in the models. The mentality behind this variable is that the more densely populated areas usually provide more infrastructure and also represent the existence of cities. It is known from empirics that agglomeration economies are an important factor for the emergence of startups at the local level (Hans & Koster, 2018). So, the question is if that is also true for the computer programming industry in the Netherlands. For local institutions and policies, the existence of universities seems to play a significant role for the growth of innovative activities and regional development. Universities have a double role, as they sometimes create university spin-offs and provide human capital to the region. As a result, the existence of universities in each municipality is used as a variable in every model. Lastly, multiple path-dependent variables are adopted in order to serve diverse theoretical arguments like the contribution of related industries for the creation of a new path, the spin-off processes of large companies and the labor pooling of specialized workforce in a region. In the context of evolutionary economic geography, a key feature is the significance of a place's economic history and its influence on future economic trajectories. As a result, it is often necessary to introduce time lags when studying the relationship between variables and dependent factors. This is done to investigate the causal connections between them.
Also, the size of each municipality in terms of firms is used as a third variable for spatial characteristics. The mentality is that due to agglomeration effects, larger local economies tend

to create endogenously more startups. So, this could also be considered as an additional variable for agglomeration economies. However, it also works as a "control" variable in order the rest of the variables to have the right coefficients and to filter out possibly wrongly included size-effects.
Construction of the models could be characterized as evolutionary, as it starts simple with three independent variables and in a second stage, additional independent variables are included. The two first variables represent 2 out of the three theoretical sections: the role of policy and institutions and the spatial characteristics of each municipality, while the third controls for the size of the regions.

$$Y = \alpha P + \beta U + \delta S + \varepsilon \qquad (1)$$

Where Y is the dependent variable in each model, P is the population density measured as the population/km2 for each municipality. U is a dummy variable (0,1) that signals the existence of a university in municipality i, serving the argument about local policies and institutions in the emergence of entrepreneurship in a region. S denotes the control variable of size, measured as the total number of all firms in year t in municipality i. The elements α β & δ serve as the parameters in each case. Lastly, ε represents the error terms in the equation.

$$Y = \alpha P + \beta U + \gamma X + \varepsilon. \qquad (2)$$

In equation (2) matrix X is included. It involves several path-dependent variables. However, these variables differ for each dependent variable, all of them serve the argument of path-dependence in evolutionary economic geography.

$$Y = \alpha P + \beta U + \gamma X + \mu + \pi + \varepsilon \qquad (3)$$

Equations (1) and (2) are regressed with a Pooled OLS technique. However, some time-invariant and time-variant observations can affect and bias the results. Space and time dimensions are introduced in equation (3) in order to filter out these effects. As a result, μ represents time fixed effects on an annual basis (as the data-period is the year) and π controls for time-invariant, cross-sectional fixed effects in the municipality scale.

3.2. Data and Tools

The main source of data is a LISA dataset regarding the registration of firms for each municipality during the period. These data include the number of firms in the sector of interest which is the "Computer programming companies and related services" (NACE code: 62). It also shows the structure of the sector, providing data about the size of companies for each local economy (e.g. as the economy of each municipality). More analytically it informs about the number of small, medium and large companies in each municipality for every year. The categorization of the size of the companies follows the criteria of EU in terms of employment, where small companies consist of 0-49 employees, medium consist of 50-249 employees and large companies have more than 250 employees (Eurostat, n.d.). One limitation of the dataset used in this study is that it captures the number of companies in each municipality only at the end of each year. This approach fails to account for changes that may occur within a given year. Therefore, although the focus was to analyze the annual inflow of new companies and jobs, this approach does not realistically capture the dynamics of such changes. For instance, there may be cases where the number of firms exiting a municipality exceeds the number of new firms entering, resulting in a decrease in the sector's presence within that municipality. However, the dataset does not include information on these new firms. Additionally, it is important to note that positive growth in a municipality during a particular year may not solely be due to internal factors promoting the creation of new firms. It could also be influenced by existing firms relocating from other municipalities to that specific location. However, within the local economy, these relocated firms may be considered as new additions. The specific dataset also informs about the number of all companies and of related industries across time in each municipality. As there is not a very specific and restricting definition about which the related industries are, the methodology followed here was to recognize the sectors with which the industry of interest trades the most. Taking into account the input-output tables of the whole country for 2018, originated from OECD, four groups of related industries emerged. It seems that the sector tends to trade most (above than 30%) with itself. Of course, this case is already investigated through the path-dependence channel, so the sector itself is not included in the related industries. The three other groups are: “Professional, scientific and technical activities” (NACE codes: 69-75), “Wholesale and retail trade and repair of motor vehicles and motorcycles” (NACE codes: 45-47) and “Administrative and support services” (NACE codes: 77-89). The whole mentality behind taking these sectors into account is to see how localized can become the value chains that are visible on the national level. In other words, we would like to see whether there is an opportunity for the sector to be developed in places where their traders are located. In addition, taking into account the Klepper’s literature about spin-offs, the variables of related companies could also examine the role of diversifiers, as parents of new computer programming firms.

Regarding the data about the existence of universities in each municipality, another route was followed. The list of all the tertiary educational institutions that were taken into account, originated from the official government website for Dutch studies (Nuffic, n.d.). Population density is defined as population/area of the municipality in Ha. Data for population are taken from the Central Bureau of Statistics (CBS), from the department of “cbs vierkant statistiek". The area of each municipality emerged from the creation of a calculation field of the shapefile of the municipalities. A caveat here is that merges of municipalities during that period aren’t taken into account, while the chosen administrative division includes 345 municipalities as they were set in January 1 of 2022. The same is also true for the area of each municipality. Even though this assumption is not realistic, it enhances the comparisons during the years. Although the administrative boundaries have changed multiple times, one could argue that the socioeconomic conditions and the local markets remain persistent.

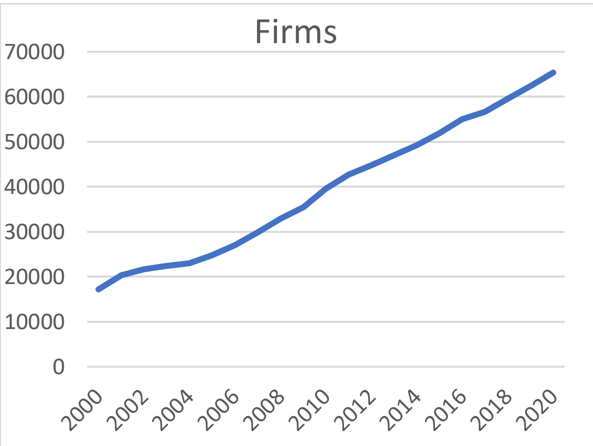
Referring to the used tools, ArcMap GIS was used in order to create thematic maps, Microsoft Excel and Stata were used to make the diagrams, to create new variables and to run the regressions.

Variable	Obs	Mean	Std. dev.	Min	Max
Year	7,245	2010	6.055719	2000	2020
Existence of university	7,245	0.0858523	0.2801652	0	1
Existence of Large companies	7,245	0.0912353	0.2879634	0	1
Size (in companies)	7,245	3348.836	6982.994	64	7903
Population density (pop/km2)	7,245	813.802	960.6853	4.535051	6991.499
Size (in jobs)	7,245	23145.91	43792.56	339	712144
Related companies	7,245	1489.82	3081.964	14	71396
Jobs in the sector	7,245	470.5928	1416.276	0	30384
LQ (companies)	7,245	0.851159	0.3313955	0	2.771587
LQ (jobs)	7,245	0.7283647	0.7485014	0	7.030675

Table 3.1: Descriptive statistics: Independent variables in their actual form. Source: own work with data from LISA

4. Results

Computer programming is a rapidly growing industry in the Netherlands during 2000-2020. Both programming firms, in figure 4.1., and jobs in the sector, in figure 4.2., present persistent increase in the selected period. The only exception seems to be a two-year period from 2002 to 2004, when someone can observe a little setback in the growth of firms and jobs in the field. While there is not a certain explanation for this phenomenon, some possible conjecture could be that as the sector was relatively new and rapidly growing around 2000's, some technological advancements increased its efficiency, which decreased the demand for jobs and new firms. Also, the fear and the uncertainty about the future of this relatively new sector, may have provoked a fear for the market to grow.
In any case, the overall image is quite clear. The number of firms more than tripled at the end of the period, as there were less than 20000 companies in 2000, while in 2020 they surpassed 60000. The number of jobs also met a big augmentation, but not as rapid as the firms, beginning with around 130000 jobs in 2000 and ending with more than 200000 jobs in 2020. So, it seems that in this 20-year period entrepreneurship played a major role for the growth of the sector in the country.



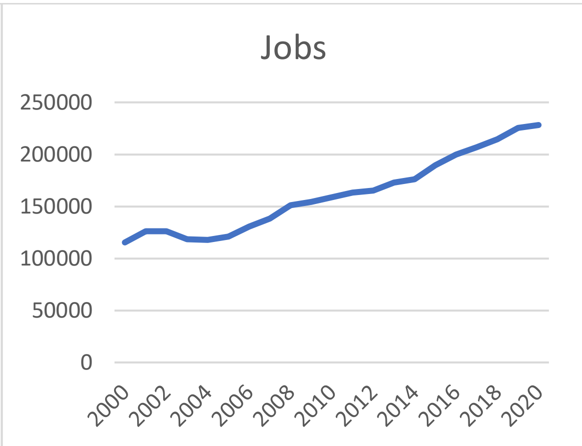


Figure 4.1: The growth of firms in the computer programming sector in the Netherlands. Source: own work with data from LISA

Figure 4.2.: the growth of jobs in the computer programming sector in the Netherlands. Source: own work with data from LISA

However, during this period, not only the specific sector was developed, but also the whole Dutch economy. So, it is interesting to see the relative growth of the sector in comparison with the national standards. Indeed, computer programming outgrew the whole economy, as its share increased over time. In 2000 it obtained 3,41% of the total employment in the Netherlands. At the same time 2,28% of the Dutch firms belonged to the computer programming sector. In 2020, both these percentages were increased with employment reaching the 6,81% and companies obtaining the 3,38% of all the Dutch firms.
Even though in total numbers entrepreneurship in programming presented a boom, which was not followed with the same intensity by jobs, the opposite happens when we compare these numbers with the national growth. Here, the smaller increase of jobs in the sector seems to be more important, as it almost tripled its share in the national economy. On the contrary, the high

augmentation in the total number of firms in the sector is not translated into such a big growth in its share in the national economy.
Regarding the business demography of the sector in the country, again small firms with less than 50 employees form the majority, owing the 97,75% of the firms in the sector in 2000 and the 99,06% in 2020. Medium firms, with less than 250 employees, and large firms obtain the 1,96% and 0,26% in 2000 and the 0,69% and 0,09% in 2020 respectively.
In total numbers, table 4.1 below shows this in 2000 and in 2020 for each category.

Size	2000	2020
small companies	16844	65016
medium companies	338	456
large companies	44	56

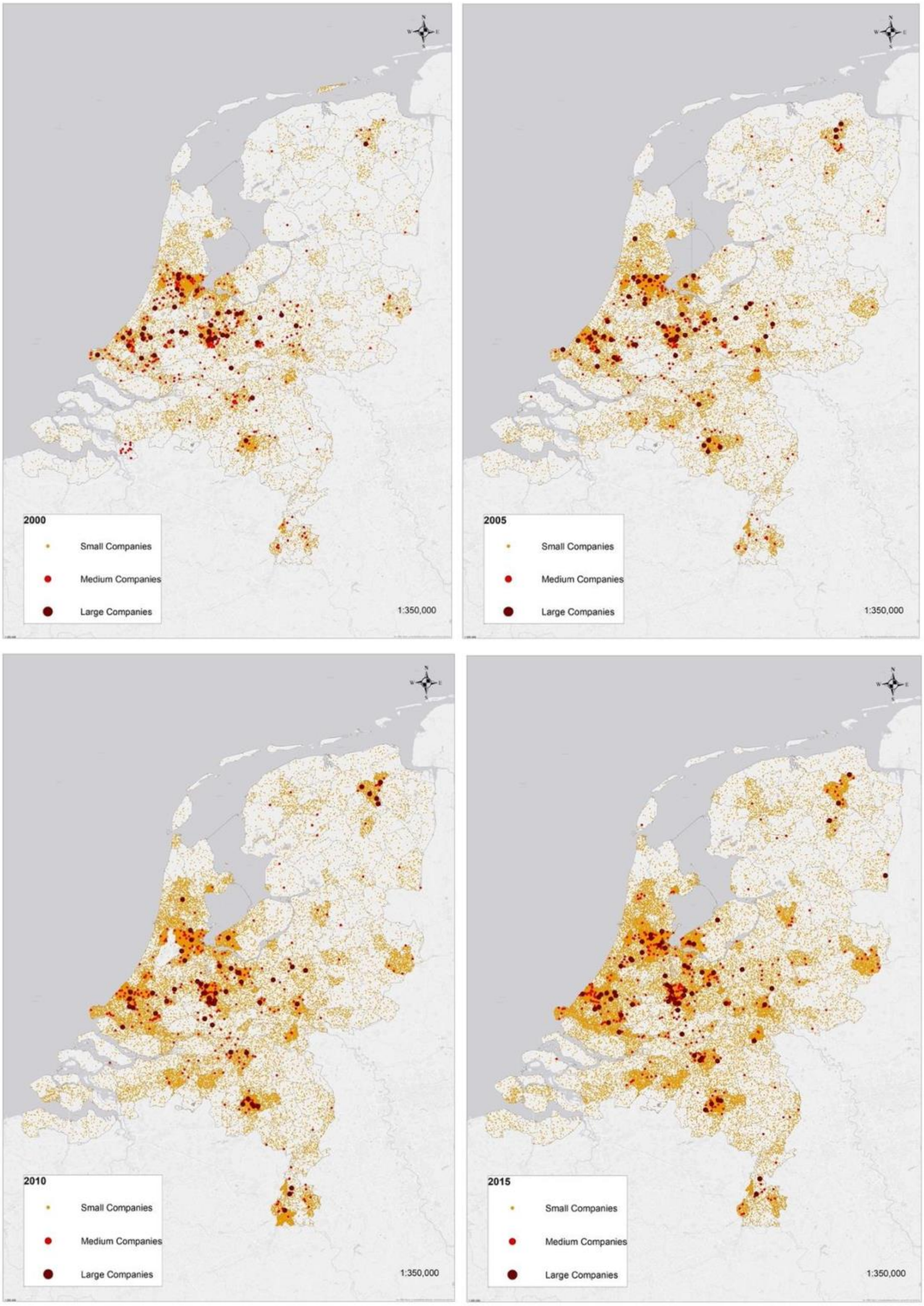
Table 4.1.: Number of programming firms in 2000 and in 2020 for small, medium and large companies. Source: Own work with data used from LISA

Although all the classes own more firms in 2020, the growth differences are obvious. Small firms constitute the dominant category, as they almost tripled in 2020, exceeding 65000 firms. Medium and large companies also have grown but at a much smaller pace. More specifically, medium companies grew by almost 35% while large companies by 27%. These increases in percentages of each category, are not correspondent with the previous percentages, where the share of each category in the total number of computer programming firms was presented. Here, the augmented percentages emerged from the different number of firms within each category. In other words, the first percentages present the evolution of the structure, while the second show the progress of each class.
In conclusion, the sector grew rapidly in the whole country. Firms followed the national standards, growing rapidly, and consisting mainly of small firms, which also determine the image for the development of the whole sector in figure 4.1. On the other hand, employment also shows a smaller but more important growth, for the national economy.

4.1. Cartographic approach

It is evident now that the sector grew fast in this 21-year period. The question is which are the spatial dimensions of this growth? In other words, where did this growth take place in the country? According to the theory, growth can be attracted by many different components like the spatial characteristics, agglomeration economies, institutions and favoring policies and economic history of the places. Focusing on the role of path-dependence, which usually stars in knowledge-based activities like the computer programming industry, we expect that the image of the country won't be very different in 2000 and in 2020, as the same municipalities should grow over time. The cartographic approach aims to reveal the role of path dependence through mapping the spatial evolution and specialization of firms and employment over time.

4.1.1. Spatial evolution



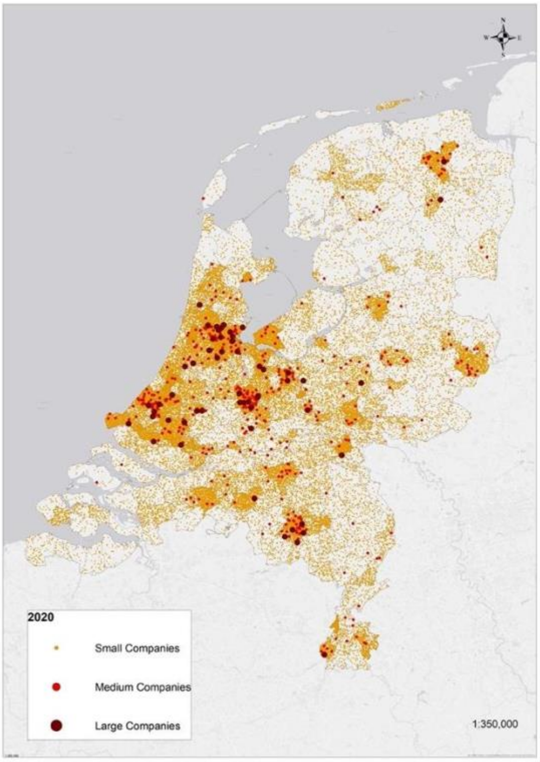
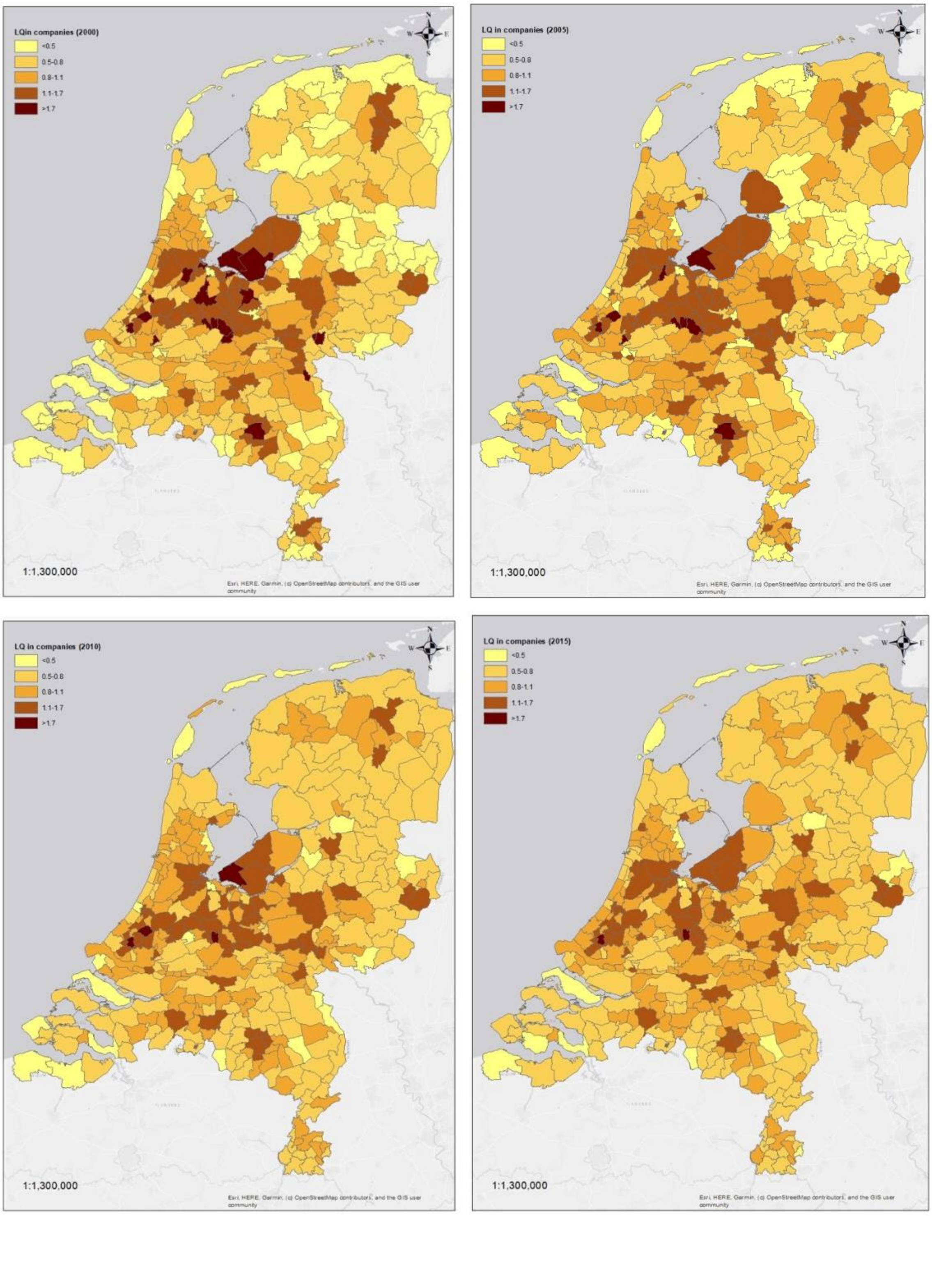


Figure 4.3.: Spatial evolution of the computer programming industry. Panels: from left top: 2000, 2005, 2010, 2015,2020. Source: own work

The first group of maps above, presents the spatial distribution of the programming industry, for every 5 years from 2000 to 2020. This 5-year interval mapping delves into the evolution during the period which is given through the changes in distribution. In addition, these maps also categorize the firms in the three known classes: small, medium and large firms. Small firms are represented by the smallest orange dot in the maps, medium companies are denoted with the medium red one, while large companies are the biggest brown dots on the maps. If someone notices the first year (2000) and the last (2020) of the period, he/she will notice that the image is quite different, as the sector is expanded (also spatially) in many new regions in the country. But let's start from the beginning. In 2000, the sector was highly localized. The majority of the firms is located in the Randstad area, where specific large, densely populated cities like Amsterdam, Utrecht, Delft and the Hague are the main hubs of concentration. The whole Randstad region is starring in the sector. However, the rural municipalities in the Randstad present significant differences in terms of developing the sector, as there are not significant concentrations there. Maps makes it visible as these regions are "whiter" than the urbanized Randstad parts. The rest of the country has been left behind in the sector. In the next few years, the growth is expanded in two directions. The first one is in the neighboring municipalities around the pillar urban hubs that were aforementioned, while the second is in specific locations in the periphery. Especially for the peripheral hubs, these locations also had smaller concentrations in 2000, which were strengthened throughout the years and became important hubs in 2020. More specifically, Groningen in the North, Hengelo and Enschede in the East, the region of Eindhoven and the neighboring municipalities and Maastricht in the South. However, the rest of the country saw a growth in the sector, as the image in 2020 is more expanded- especially in the southern part of the country in 2020 than the highly localized concentration in Randstad in 2000.

Last but not least, the difference in locational behavior among small, medium and large firms is interesting. While small firms have been developed all over the country, medium and large companies present a common behavior, preferring the same locations over time. These locations are: Randstad and especially Amsterdam, Delft, Utrecht and the Hague, but also some other locations around Apeldoorn and Ede outside the main concentration.

4.1.2. Evolution of specialization (firms)



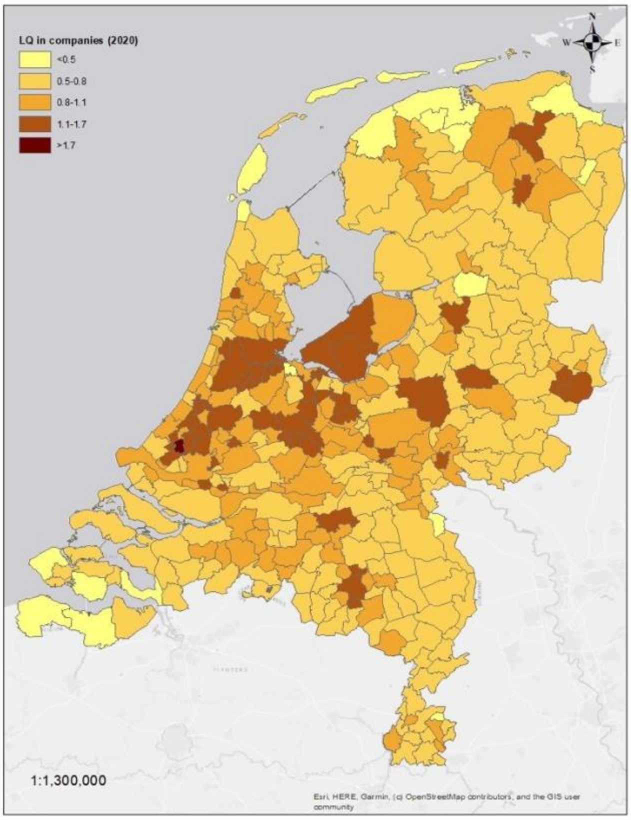


Figure 4.4.: Evolution of specialization of computer programming firms. Panels: from top left: 2000, 2005, 2010, 2015, 2020. Source: own work

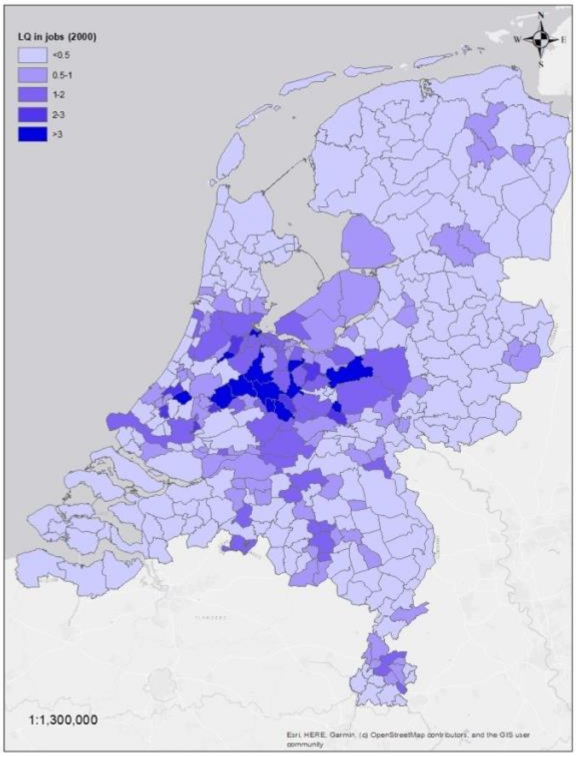
This second group examines the evolution of the Location Quotient of firms every 5 years. As it was explained from the methodology part, Location Quotient is an index of specialization. In other words, this group investigates the path of specialization for every Dutch municipality over the years. The municipalities are divided into 5 different classes of specialization, where the Location Quotient index takes the following range-values: (1). <0.5., (2) 0.5-0.8, (3) 0.8-1.1, (4) 1.1-1.7 (5) >1.7. The municipalities in the two first categories with the yellow and light orange colors respectively, are the underrepresented areas, in terms of programming firms in their local economies. The third class is the average class which signals the national average, as its values are around 1. The two last categories refer to the specialized municipalities where the existence of programming firms is dominant in the local economy. Especially in the highest category the specialization index exceeds 1.7, which means that they are more specialized than the national level by 70%. The difference with the spatial evolution is that here the concentrations in dense cities are not necessarily translated into a high level of specialization, as they could be only a small part of a very large and broad economy. So, here, someone can see that regions with only a few firms could be highly specialized, as these firms are the dominant sector in a small local economy.

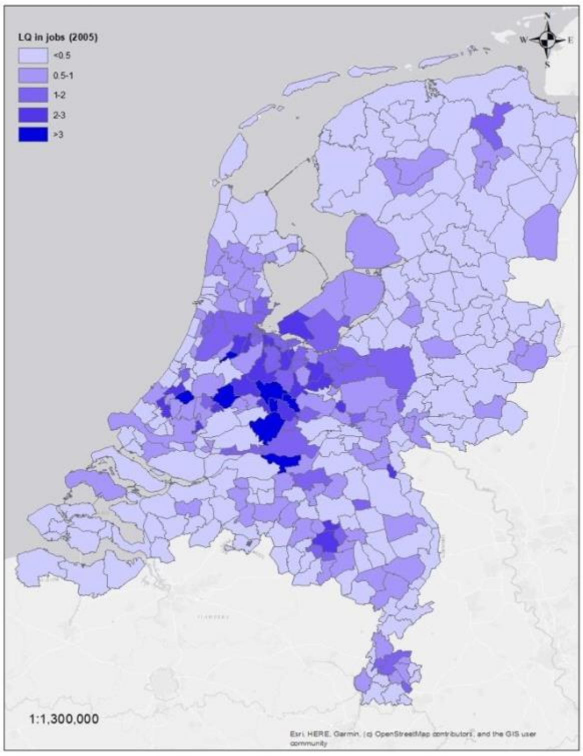
In 2000 the majority of specialized areas were in the Randstad area, where the main concentration was located. Even though the main hubs (Amsterdam, Utrecht, the Hague) are quite specialized being in the second highest category, they are not in the first one, as probably their large urbanized economies keep them from being highly specialized. The only exception is Delft, where its high concentration is translated into a high LQ (1.93). However, there are some neighboring municipalities around the main hubs, which present extremely high specialization, like Amstelveen close to Amsterdam, Houten near Utrecht and Zoeterwoude for the Hague. This fact probably reveals that there are channels of interdependence among neighboring regions and that also the geography of each region matters. In general, there is a gradual decrease in specialization. The specialized Randstad is surrounded by an area which is in the third national average category, and continues with more isolated peripheral areas which are underrepresented in terms of programming firms. Some exceptions are specific municipalities in the periphery that turn out to be hubs in the future like Groningen, Enschede, Hengelo and Eindhoven.

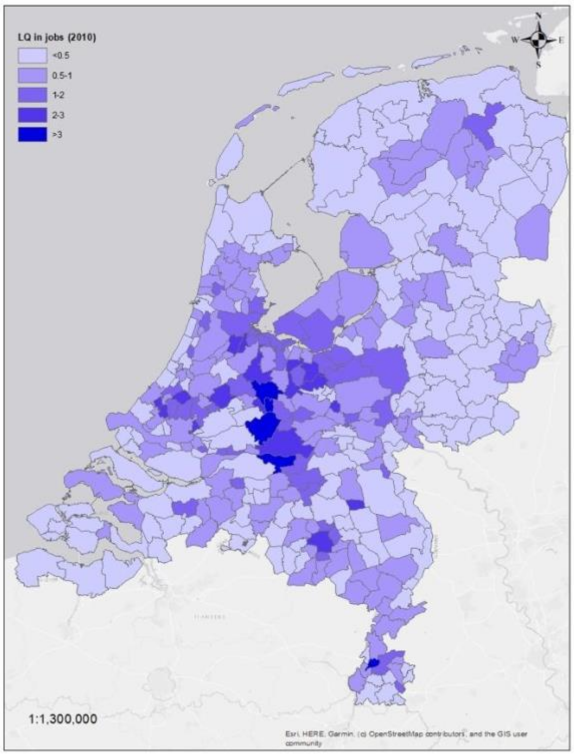
The image is not so different after five years, but it has notably changed after ten years, in 2010. There is a significant decrease in the number of very specialized municipalities, where LQ is greater than 1.7, but also many municipalities, especially from the lowest class, grew rapidly and managed to level up in the second lowest class. This pattern of convergence continues in the next decade, too, when almost the whole country belongs to the three middle classes of specialization. The path of the spatial convergence during time is not entirely aligned with the aforementioned theoretical discussions. On the contrary, high growth of the first clusters was expected, making the spatial distribution of the activity more and more spatially uneven. The specific result of firms' sprawling reveals that the computer programming industry follows a unique path and is not entirely shaped by the theoretical arguments. It also highlights the importance of spatial interaction among municipalities, while alternative factors like interregional networks could also mater.

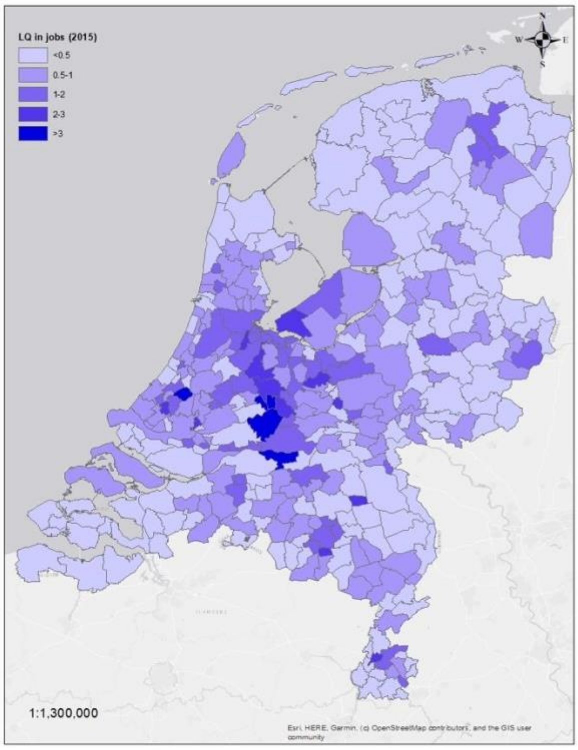
It seems that there is a pattern of convergence, as many highly specialized municipalities leveled-down in a specialization category, while the opposite happened for the most underrepresented regions where the sector grew rapidly during the period, and as a result they managed to level-up in a higher category of specialization. Especially, for the highest rank, it is interesting that the Netherlands had 17 municipalities in it in 2000, while only Delft remained in the same category in 2020. However, it is also important to understand that the number of specialized municipalities in the two highest classes remained the same over the years, which indicates that paths of specialization are difficult to change, even after 20 years.

4.1.3. Evolution of specialization (employment)









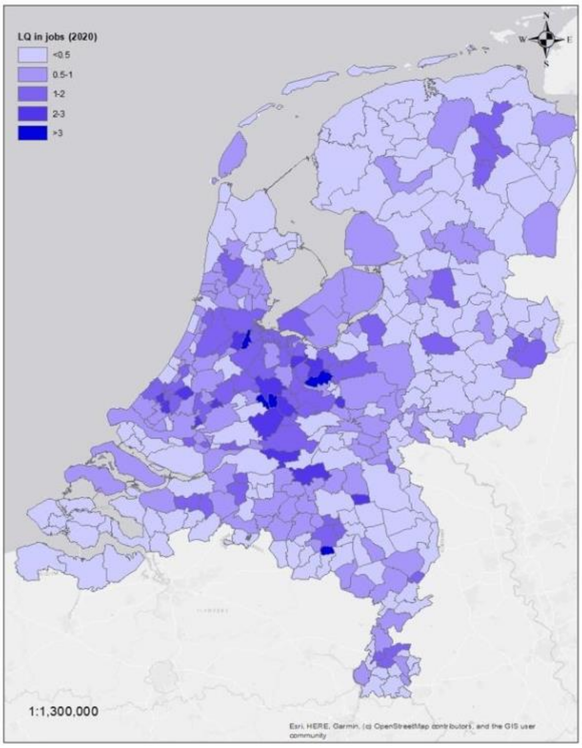


Figure 4.5.:Evolution of specialization in computer programming employment. Panels: from top left: 2000, 2005, 2010, 2015, 2020. Source: own work

The third and last group of maps present the evolution of specialization of employment in each Dutch municipality over time. Again, there are 5 different classes of specialization: (1) <0.5 (2) 0.5-1 (3)1-2 (4) 2-3 and (5) >3. The difference here is that the levels of specialization are remarkably higher than the ones of firms. The highest class of firms exceeds 1.7 while for employment it surpasses 3. This indicates that the distribution of employment is concentrating more unevenly, in specific highly specialized "employment centers". Similarly with the case of companies, the first two categories refer to underrepresented regions while the rest of them are about specialized municipalities. Staring from 2000, there is an evident core-periphery pattern, where the Randstad area is specialized in employment of programming, while its share in the rest of the country is lower than half of the national. Also, most of these employment hubs are in specialized municipalities in terms of firms, too. Gradually, this image changes and the employment centers change over time, shifting mainly to the southern part of the country. Likewise with the evolution of specialization of firms, the most specialized municipalities job-wise, are reduced over time. At the beginning of the era there are 14 "employment centers" in the highest class, while at the end there are only 4. The spatial evolution of employment is equivalent to that of firms in the sense that someone can notice that the southern part of the country is mostly developed during the period. However, in employment, convergence is not happening. Indeed, there is a change in specialization, but still in 2020 there are immense differences in specialization of employment among the municipalities. The vast majority in the lowest class in 2000 remained underrepresented at the same degree. The fast growth of entrepreneurship in those regions wasn't followed by rapid increase in employment, at least in a degree that would allow them to level up a class of specialization. On the contrary, employment specialization seems to take place after the emergence of strong hubs in the periphery, but also in municipalities where there are medium and mostly large companies, which seem to be the main providers of jobs. Another distinction in the evolution of specialization of employment, is the absence of gradual spatially decline

in specialization. On the contrary, many neighboring municipalities of employment centers in the periphery are in the lowest class, a thing that is not happening in the Randstad area. This observation also implies the different nature of emergence and function of peripheral hubs which work as magnets of employment for the surrounding area. On the contrary, in the Randstad area the proximity with big employment centers proves to be beneficial for the sector's employment growth. In this context, the role of policy-making, the existence of supportive infrastructure and institutions in the urbanized Randstad in comparison with other rural areas, could be good explanations for the different spatial behavior of the sector.
In conclusion, the sector has an expansive character in terms of firms over time. While the image of convergence is obvious, the specialized hubs remain the same over the years, indicating the strong path-dependent nature of a development trajectory, which is difficult to change. On the other hand, employment seems to be more volatile. It is obvious that the southern part of the country has developed significantly, both for firms and for employment. However, the two last groups of maps revealed different spatial patterns for firms and employment, implying that entrepreneurship doesn't go vis-à-vis with jobs, at least in the first place. The different paths are probably a result of different underlying mechanisms for each process. These mechanisms are investigated in the next econometric part.

4.2. Econometric approach

The cartographic approach presented the spatial evolution of firms and employment over time in the country , highlighting the importance of geography. While this first step of the analysis enabled the observation of the phenomenon, this second step tries to find the causes for the observed spatial patterns, through an econometric approach. Taking into account all the theoretical arguments, independent variables relating to path-dependence, agglomeration economies and the existence of universities are included. In that way, the econometric approach also answers all the three sub-questions for the possible underlying mechanisms for the spatial evolution of the sector. On the contrary with the previous approach, this step follows a mentality of urban economics, focusing only in the internal conditions of the municipality and not in the geography as potential channel for development. It examines three basic dependent variables, while there are three different equations for each one, as they were explained in the section 3.

4.2.1. Size of the sector

The first dependent variable is the size of the sector which is translated into the number of computer programming companies in year t. The aim is to see where the hubs are concentrated in the country. In other words, the scope of the series of regression for the size of the sector is to understand the spatial and economic characteristics of the municipalities that host the main concentrations of the sector. So, the first regression in table 4.2. below, denotes the equation (1) from the methodology part, which examines the spatial characteristics of each municipality. These spatial characteristics are the existence of universities, the population density, which signals the agglomeration economies and the size of the municipality in terms of firms. As path dependent variables, the number of companies in related industries, the existence of large companies and the number of jobs in the sector, are selected. Due to the fact that most of them are examined for the same year t, causality can't be assumed. So, in that case, these variables represent the structure of the local market rather than path-dependent variables that are responsible for the existence of hubs. The number of firms in related industries aim to see whether there is a local concentration of trading industries in the same regions. Put differently, if the concentration of a sector in a municipality gives an incentive for supplier or/and customer industries to be located in proximity. This also works as a harbinger for the role of related companies in the emergence of new companies in the same municipality, which is investigated below. The existence of large companies is represented by a binary variable (0 or 1). The drawback of the binary variable, is that it does not count the population of large companies but only the existence of them. So, every municipality that has one or more large companies has the value of 1. While some large cities with many firms also have multiple large firms, the logic behind the adoption of this dummy variable is to examine what happens to the concentration of firms in regions where there are large companies. In other words, the variable is centered around regions and not the locational behavior of large firms. Last but not least, the number of jobs in the sector is a good indicator to see if firms and jobs go vis-à-vis, or whether other factors determine the levels of employment in computer programming (like medium and large firms).

Dependent variable: The logarithm of existing number of companies in computer programming sector			
VARIABLES	*(1)* *Pooled OLS*	*(2)* *Pooled OLS*	*(3)* *Time and cross-sectional fixed effects*
Existence of university	*0.05* *(0.017)***	*0.037* *(0.013)***	*0.07* *(0.024)***
Log of population density	*0.11* *(0.0047)****	*0.020* *(0.003)****	*-0.35* *(0.057)****
Log of all companies	*1.16* *(0.0064)****	*0.93* *(0.032)****	*1.38* *(0.054)****
Log of related companies	-	*-0.217* *(0.033)****	*-0.19* *(0.053)****
Existence of large companies	-	*-0.24* *(0.014)****	*-0.16* *(0.011)****
Log of jobs in the sector	-	*0.37* *(0.005)****	*0.31* *(0.0052)****
Constant	*-5.58* *(0.95)***	-	-
Standard errors in parentheses ****p<0.001, **p<0.01, *p<0.05, + p<0.1*			

Table 4.2: Regression for the size of the sector. Source: own work

Table 4.2. consists of 3 columns, representing the 3 different equations in the methodology in part 3. In the first two columns, Pooled OLS regressions took place, while at the last one, time and space dimensions were added, transforming the linear regression into a spatial model. Since the provided dataset consists of spatial panel data, the coefficients in the last columns seem to be the most valid. For the population of the computer programming companies, the logarithm of the variable is used as a dependent variable. Similarly, all the count independent variables, which are the number of all companies, the number of related companies, the jobs in the sector but also the population density are transformed into their logarithmic format. The dummy variables remained the same.

In the first column, where only the spatial characteristics of the regions are examined, it is obvious that all independent variables are statistically significant, with the size of the municipality to dominate, as it exceeds 1. This means that if the size of a municipality increases by 1%, then the number of computer programming companies will rise by 1.16%. The existence of university, which is the only dummy variable in this column, is positive and significant. Its coefficient of 0.05 means that the existence of university in the regions contributes by exp(0.05) that equals to 1.05 of the number of companies. In other words, the existence of a university raises the number of computer programming companies by 5%. In the second column the structural economic variables are added. The importance of these variables is depicted through two channels. The first one is that all of them are statistically significant. The second channel is that, after the introduction of the structural variables, the coefficients of the spatial characteristics used in the first column are reduced, which means that a part of them in the first column was a result of other factors that weren't taken into account. However, all of them remain positive and statistically significant. From the structural factors, only the number of jobs in the sector goes vis-à-vis with the number of companies. Large companies and related companies present negative coefficients. Especially for the existence of large companies, which is the second dummy variable, its existence decreases the number of companies by 21%, as exp(-0.24)=0.79, so its negative contribution is calculated by 1-0.79=0.21. The rest of the variables are count variables and are interpreted as the percentage increase or decrease of the dependent. Variables, like the contribution of the size, were explained in the first column. Last but not least, time and space dimensions are introduced in the last column. The majority of coefficients are decreased again, implying the effectiveness of the technique. By adding these dimensions, we are able to follow the evolution of every municipality regarding the changes in the independent variables, as the system recognizes each municipality like an entity that is examined for 21 years and not just simple observations. As a result, this technique enables us to filter out every unobserved heterogeneity due to time and space. The most important difference here is that the population density becomes negative. This is in contrast with the previous two columns, where it contributes positively. A possible explanation of this could be that even though in general population density is positively related with the number of companies in the sector, when we follow the path of each municipality in the last column, the population density is not a beneficial element for the emergence of new hubs, as it decreases the number of firms by 0.3%. In other words, this last column also works as a harbinger for the patterns of evolution of new concentrations in the sector. Indeed, some of the municipalities, like Hengelo, Enschede and Groningen, where new hubs emerged, present moderate population densities.

In short, the regressions validate the monitoring of the maps. The hubs seem to be concentrated in large densely populated areas, while the employment is related with the existence of hubs, which is denoted by the positive relation of firms and employment. The existence of universities and the size of the municipality are also valuable factors for the number of firms. So, it seems that large local markets are supportive environments for the computer programming industry.

4.2.2. The growth of firms of the sector

A similar approach has been adopted for the growth of the sector. The dependent variable here is the change of the companies in the sector for every municipality and year which is calculated as: number of companies in year t-the number of companies in year t-1. So, the growth of the sector can be positive but also negative in some cases, where the number of firms reduces. For the examination of the growth of firms, an additional step accompanies the three equations introduced in the methodological section. To be more specific, while the first column denotes the first equation, where only the spatial characteristics are used, the addition of the path-dependent variables is realized in two steps, in the second and third column in table 4.3. In the second column, time-lags of the growth of firms are put in from year t-1 back to year t-5. The selection of the first 5 years emerged from the literature, where Brixy & Grotz, (2007) support that for new innovative and technological industries, the first 5 years are the most important for the survival and the establishment of the startups in the market, as the changes and the advancements are rapid, that leads to rapid changes in entrepreneurial activity. However, here the time-lagged variables play a role which is closely related to the theoretical core of path-dependence. The main aim of them is to see whether the evolution of growth- either positive or negative- presents the same patterns. To put it in another way, we try to see whether a positive growth of the sector is self-reinforced and creates the foundation for other new companies to be established in the sector within the first 5 years. In the third column the rest of the path-dependents are added. More analytically, the existence of large firms, the number of jobs and the number of related companies, are now time-lagged in t-1. This happened in order to see how the structural factors in the previous year, create a favorable environment and give incentives for new companies in the sector to emerge. Especially for the large companies, this could also be an indicator of their diffusion of spin-off companies in the same region, while the number of jobs highlights the Marshallian advantage of the labor pooling in the sector. In the fourth column time and space dimensions are added, while the fifth column presents an alternative path-dependent variable of the LQ for firms in the previous year, instead of the time lags of growth of firms in the sector.

Dependent variable: Change in companies					
VARIABLES	*(1) Pooled OLS*	*(2) Pooled OLS*	*(3) Pooled OLS*	*(4) Time and cross-sectional fixed effects*	*(5) Time and cross-sectional fixed effects*
Population density (t-1)	*0.00033 (0.00017)**	*0.00046 (0.00020)***	*0.024 (0.0042)***	*0.023 (0.004)*	*0.0098 (0.0033)*
Existence of university	*1.67 (0.63)***	*1.41 (0.68)***	*1.07 (0.69)**	*1.79 (0.70)**	*1.8 (0.93)**
Number of all companies	*0.0028 (0.000025)****	*0.0020 (0.00007)****	*0.005 (0.00015)****	*0.013 (0.004)****	*0.016 (0.0004)****
LQ in companies (t-1)	-	-	-	-	*-9.14 (1.10)****
New companies (t-1)	-	*0.13 (0.013)****	*0.10 (0.014)****	*0.024 (0.013)*	-
New companies (t-2)	-	*0.24 (0.014)****	*0.20 (0.014)****	*0.15 (0.013)****	-
New companies (t-3)	-	*-0.047 (0.014)***	*-0.063 (0.013)****	*-0.01 (0.013)*	-
New companies (t-4)	-	*-0.10 (0.014)****	*-0.14 (0.013)****	*-0.05 (0.014)****	-
New companies (t-5)	-	*0.08 (0.014)****	*0.05 (0.014)****	*0.07 (0.013)****	-
Number of related companies (t-1)	-	-	*0.007 (0.0008)****	*0.029 (0.0012)****	*0.034 (0.0012)****
Existence of large companies (t-1)	-	-	*-2.06 (0.76)***	*-0.68 (1.19)*	*-2.33 (0.68)*
Jobs in the sector (t-1)	-	-	*0.003 (0.0002)****	*-0.0043 (0.00070)****	*-0.0038 (0.00084)****
Constant	*0.044 (0.34)*	-	-	-	-
Standard errors in parentheses					
****p<0.001, **p<0.01, *p<0.05, + p<0.1*					

Table 4.3.: Regression for the growth of firms of the sector. Source: own work

Every step seems to be helpful as the coefficients are reduced and their statistical significance changes. The size of the municipality in terms of firms is a steadily significant factor for growth, which means that the larger the local economy, the larger the growth in companies in computer programming. Population density seems to be positive but it becomes insignificant when time and space dimensions are introduced, which means that progressively the sector tends to expand in other regions, too. This is also aligned with the observations of the maps. The existence of a university is also important for entrepreneurial activity in the sector. Regarding the time-lagged variables of growth of companies, they show a consistent pattern with the two first years being positive, the third and fourth year being negative and then the fifth year being positive again. Since, we are talking about the change in number of firms, regions present a cyclical pattern throughout the 5-year era. Even though there isn't a certain explanation for the fluctuations, a possible story could be the following. The first two years of positive growth in the regions could easily represent a local trend, where the sector is growing. However, the negative coefficients of the third and fourth year could be the result of the failure of most of these startups. According to Howarth (2023), statistics show that 70% of the startups of all the industries fail from the second to fifth year. In this case, it would result in the total decrease of the sector in terms of firms at the municipal level. About the coefficient of the fifth year, a possible explanation is that the startups that have survived, have set their foundations in the local market. They have had enough time to develop their personal local networks, to produce and exchange knowledge in the market but also to attract and train the workforce. To put it differently they have enough time to create positive externalities in the regions in order for new companies in the sector to emerge. Nevertheless, the contribution of the fifth year is the lowest positive in comparison with the first two years, where the impact is stronger. However, when space and time dimensions are added, the contribution of the previous year (t-1) becomes very small and statistically insignificant. When the Location Quotient is used, its coefficient is negative and strongly significant. So, the Marshallian idea about the specialization producing innovation and startups doesn't apply in the computer programming sector. This result is also aligned with the evolution of the maps, as there is a convergence in the distribution of firms at the end of the period as there is slow downside change of LQ classes in the very specialized regions and the upward trending in the growth of the computer programming firms in the most underrepresented regions. Related companies are also a beneficial factor for the emergence of new companies in programming in a region, while the abundance of jobs in the sector in the previous year works negatively. This last fact counteracts the theoretical argument of labor pooling that gives incentives for a sector to grow further in a region. A possible explanation is that the existence of many jobs in the sector makes the opportunity cost of starting a new business relatively expensive for high-skilled people. Last but not least, the existence of large firms in a municipality, is a negative non-significant factor, indicating that spin-off processes are not evident in the programming. On the contrary, someone could argue that large firms work as centrifugal factors for concentrations of companies to emerge, as its coefficient is also negative and significant in the previous part.

4.2.3. Growth of employment

The last dependent variable refers to the employment and more specifically to the change of employment measured as the difference of jobs in the sector in year t and t-1.Once again, the logarithmic format of the variable was used, like it happened for the size of the sector in the first part. The rest of the independent variables were also used in their logarithmic formats with exception being the two dummy variables: the existence of university and of large firms in the region and the number of new companies. In table 4.4., the three columns represent the three different equations (1), (2) and (3) from section 3, respectively. The path dependent variables introduced in the second step are the Location Quotient of employment in the previous year, the new companies in the sector and the existence of large companies in the municipality. The two last variables examine the main contributors of employment in terms of companies.

Dependent variable: Logarithm of change in jobs in computer programming industry			
VARIABLES	(1) Pooled OLS	(2) Pooled OLS	(3) *Time and cross-sectional fixed effects*
Log of population density	0.19 (0.018)***	0.88 (0.018)***	-0.32 (0.56)
Existence of university	0.30 (0.067)***	0.01 (0.06)	-0.03 (0.24)
Log of number of all jobs	0.81 (0.023)***	0.67 (0.034)***	1.08 (0.26)***
LQ in jobs (t-1)	-	0.58 (0.03)***	-0.09 (0.56)
New companies	-	0.006 (0.0006)***	0.014 (0.001)***
Existence of Large companies	-	0.12 (0.07)+	0.24 (0.11)**
Constant	-6.41 (0.20)	-	-
Standard errors in parentheses ****p<0.001, **p<0.01, *p<0.05, + p<0.1*			

Table 4.4.: Regressions for employment. Source: own work

The results of employment are somewhat different from the results of companies. Regarding the spatial characteristics, it is evident that the only consistent factor contributing to job growth in the sector is the size of the workforce. Even though the university is positive and significant in the first equation, in the second it becomes insignificant, while in the third it also becomes insignificant and negative. This reveals that the role of universities as providers of specialized human capital isn't significant for the creation of new jobs in the regions where the universities are located. However, the main difference is about the role of large companies. While they work as a pull factor for new entrepreneurial activity in the field, here they seem to be the main providers of jobs. Their contribution becomes even larger and more significant when space and time dimensions are added. The existence of a large company in a municipality increases the number of jobs in programming by 12%, as the exponential of 0.12 in the second column equals 1.12. Similarly, In the third column the existence of large companies increases the growth of jobs by 27%. The growth of companies also offers new jobs in the municipality. In the third column, where space and time dimensions are added in the model, the coefficient increases from 0.006 to 0.014. Following the same process as in large firms, the increase of the variable by 1% is translated into an increase in jobs by 0.6% and 1.4% in the second and third column respectively. Conclusively, even though both new entrepreneurial activity in the sector and the existence of large firms offer new jobs in the municipality, the last factor presents much larger effects in employment. Nevertheless, the statistical significance is stronger for new companies than for large firms, indicating that new companies almost always produce some jobs, while large companies most of the time offer more new jobs in the sector. This can also be seen with the employment centers observed in the maps, where there is a high specialization of employment, which is not presented in the case of firms. Probably, the existence of large companies is the main cause of these centers.

5. Conclusions and future research

5.1. Conclusions

Due to the dynamic element of time in the analysis, the project mainly focuses on the role of path-dependence for the development of the sector. The contribution of the institutional aspect and the socio-spatial characteristics is examined through the role of university and agglomeration economies respectively. According to the theory, independently from the sector but mainly for high-tech industries, all these three elements are decisive strengthening factors for the emergence of new firms. However, as it was described in the introduction, the personal interest for the specific sector emerged from its special characteristics. The alternative way of communication through coding that could transfer knowledge through distance, the rising trend of remote working in the sector, and the lack of transportation costs for the delivery of the services, can strongly affect the locational patterns of firms and employment over time.

The computer programming industry has been a steadily growing sector for the selected period in the Netherlands. The number of jobs and firms doubled and tripled during the 21-year era respectively. Regarding the spatial pattern of this increase, the whole image presents spatial expansion of the firms as the time passes. The sprawling of firms starts from the neighboring regions and is extended in the periphery after a while. This is also visible from the shift of LQ classes for the extreme cases (most specialized and most underrepresented regions) to a more moderate category, which implies a process of spatial convergence in terms of firms. However, the majority of the specialized regions (where LQ>1) remains persistent over time, which justifies the path-dependent argument about the selection of regional and development paths that can't change easily, even after 20 years.

But why did that spatial expansion of firms take place? Beside the special characteristics of the sector that could play a role in the sprawling of the sector, other factors also could determine its spatial evolution. First of all, even though the computer programming industry is considered as an innovative industry in general, not every new firm is innovative! The methodology adopted for the spatial evolution describes the development of an industry and not the location pattern of pure innovation. But even within the selected period, the change of the image and the emergence of new hubs could tell a story about the originality of the sector. Even though there is not a certain answer, this could be a possible story. At the beginning of the era, in 2000, when the activity was still relatively new, there was a clear concentration in specific municipalities in the Randstad area. These municipalities represent large densely populated cities, where universities exist. However, in 2020, the sprawling of the firms in the neighboring regions and in the periphery was evident. To put it differently, in 2000, when possibly the newness of the technology was closely related with innovation and exchange of tacit knowledge, the spatial pattern of the sector seems to follow the theoretical arguments about high localization in specific locations. However, as the technological advancements were extremely rapid, the technology stopped being so original, but more widespread, which had an obvious spatial impact in the spatial expansion of the firms. To put it simply, the openness of the technology led also to the spatial expansion of the sector, which is also evident from the econometric part, where population density-that represents agglomeration economies- is not a significant factor for the growth of the sector.

Employment on the other hand follows different paths. Indeed, there is a change in the image of employment during the period, too. However, the distribution of employment and the spatial patterns of employment are quite different from the entrepreneurial ones. The higher levels of specialization in comparison with the specialization levels of firms, reveal the uneven distribution of employment in space. The employment centers of programming (where LQ>2 and LQ>3) imply different channels of growth and other factors that provoke employment. Indeed, in contrast with the growth of firms, the existence of large companies seems to be the main supplier of jobs in programming, while new entrepreneurial activity doesn't "produce" so many new jobs. Of course, this could be expected even from the demographics of the firms, where the detrimental majority consist of firms with less than 50 employees. From the geographical perspective, employment centers have a different impact on their neighbors, which depends on their location in the country. More analytically, employment centers in the urbanized Randstad area favor the employment in the sector nearby, while in the periphery, they work as magnets of human capital, leaving the surrounding area depleted. This differentiation reveals that other socio-spatial factors like agglomeration economies, urban systems and metropolitan areas also affect the spatial patterns of employment.

The relation between employment and firms' growth strengthens the story about the openness of technology and the spatial sprawling of firms. Following the discussion of Nelson & Winter, (2004) and Winter, (1984) about the diverse technological regimes in different industries and their relation with the creation of employment by Audretsch & Fritsch, (2002), the computer programming industry seems to be a revolving door, as the growth of companies isn't followed by a relative growth of employment. More analytically, in such industries, the entry is quite imitative and it isn't accompanied with high growth of employment as the technological regime is quite prevalent. The computer programming industry in the Netherlands presents a correlation between growth of companies and jobs, of 0.54. In order to assess this number, the relative correlation for the whole Dutch market took place, with the result being 0.74. As a result, new companies in coding create much lower employment in comparison with the entire Dutch market.

In conclusion, the empirical part for the computer programming industry validates some aspects of the theory. Especially for path-dependence, it is a strong factor that affects the evolution of the sector. However, it doesn't always work beneficially. Indeed, selected local trajectories that lead to specialization are difficult to change, sometimes indicating the lock-in of regions in specific industries and technologies. However, municipalities that had an initial advantage in the sector are not beneficial for the growth of the sector in terms of firms. On the contrary, high specialization provokes strong negative effects for new firm formation, probably due to the saturation of the local market. The abundance of jobs in the sector makes the opportunity cost expensive for people to start their own firms, counteracting the advantage of labor pooling in the region. From the econometric part, spin-off processes from large firms can't be assumed as the coefficient is negative and non-significant. Beneficial factors are the existence of universities and related companies. Also, the growth of companies proved to be dependent on past growth sectoral patterns in the region, where a 5-year period presents fluctuations which are aligned with the statistics for the trends of emergence and survival for startups in an industry. On the other hand, employment seems to follow entrepreneurship in a region, when the latter is successful. The success of entrepreneurial activity in a region is evident through two channels: the first one is when there is a large number of firms in the municipality (when there is a hub of programming companies) and the second one is when specific companies enlarge in size.

So, the empirical evidence partially validates the expectations from the conceptual model about new entrepreneurial activity in the programming sector. Indeed, some aspects like universities contribute significantly to the growth of firms However, the whole image is not entirely what it was expected from the theory. According to the theory, the uneven spatial distribution of the sector with a gap that would grow over time, due to the high-tech , innovative character of the industry, would make sense, the results show otherwise. Of course for the expansive character of the in the emergence of companies, the spatial interactions among neighboring municipalities and the followed methodology should be taken into account. As it was mentioned before, not all the firms in the sector are innovative, while their spatial expansion could mean the widespread of the technology. There seem to be two main take-away messages, The first one is that path-dependence, which was the primary determinant, matter. However its contribution is not always positive as it is suggested from the theory. High specialization in specific municipalities lead to lock-in effects which makes it difficult for new entrepreneurial activity in the sector to emerge. The second is that there is a time lag between employment and entrepreneurship in the sector.

5.2. Future research

But why do we care about the spatial evolution of the specific sector? Understanding the distribution of economic activity can unveil patterns of wealth distribution and spatial inequalities. Economic geography, as a field of social science, aims to address and mitigate social and economic disparities. By examining the distribution and evolution of economic activity over time, as well as the factors driving these changes, policymakers can gain valuable insights and develop more effective strategies for regional development in the future. Especially for the computer programming industry, which is a high-tech sector, it has witnessed spatial sprawling over years extending beyond the main urban hubs in the country and even giving rise to new centers in suburban and rural areas. This presents an opportunity for these peripheral regions to embark on new development trajectories and reduce the development gap with larger cities. However, it is important to note that this cannot be approached with a one-size-fits-all strategy for all rural and suburban areas. On the contrary, someone has to think about the uniqueness of each region and its position in the map. Following the discussion of Elhorst (2010) it is expected that there is spatial interaction among regions for the emergence of entrepreneurship. From the observation of the maps, it is evident that the main sprawling patterns of firms take place like a surrounding belt from Randstad in the North Holland, in Gelderland and in the major cities in North Brabant (such as Eindhoven, Tilburg, 's-Herogesboch). While the econometric analysis here adopts an urban economics approach, focusing on the conditions within each municipality, it would be beneficial for future research to explore how the growth of the sector in neighboring regions can impact the examined municipality's growth. Furthermore, the choice of the municipal level for this research is justified by the fact that the underlying mechanisms described in the theoretical framework primarily operate at the local level. However, it is worth noting that many individuals live in a different municipality from where they work or study, and this has spatial implications for the emergence of firms and employment. Commuters bring their acquired knowledge back home, influencing the local dynamics.

The selected 21-year period reveals a kind of convergence in terms of firms for the Netherlands. A great development both in terms of firms and employment in the sector in the southern part of the country has been noticed, too. Which would be the image in 2040? Will this pattern of convergence continue? And now another factor should also be taken into account, as the introduction of Artificial intelligence (AI) in our lives can have immense impact in the way that we learn and work. Harvard University has already decided to use AI as supportive teaching staff from the new semester, aiming to increase the ratio of students and teachers to 1:1 (Donlevy, 2023). If the tacit knowledge is transferred through distance in limited level through coding, the AI's spatial repercussions are expected to be even bigger, and work as a spreading factor for firms and employment in the future.

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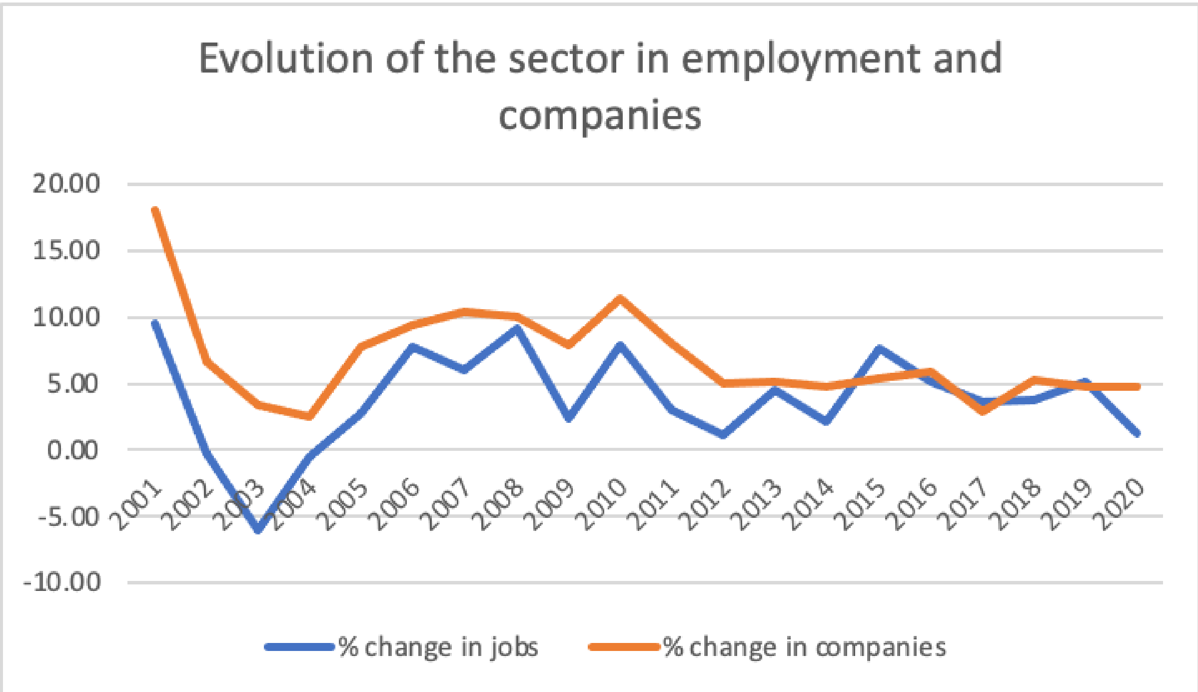
Appendix

	2000	***2020***
small companies	*16844*	*65016*
medium companies	*338*	*456*
large companies	*44*	*56*

	% of all companies (2000)	***%of all companies (2020)***	***% change 2020-2000***
Small companies in software	*97.75%*	*99.06%*	*285.99%*
Medium companies in software	*1.96%*	*0.69%*	*34.91%*
Large companies in software	*0.26%*	*0.09%*	*27.27%*



List of tertiary education (institutions)
Leiden University
University of Groningen
Maastricht University
Radboud University
Vrije Universiteit Amsterdam
Utrecht University
University of Amsterdam
Tilburg University
Erasmus University Rotterdam
Wageningen University & Research
University of Twente
IHE Delft Institute for Water Education
Wittenborg University of Applied Sciences
Eindhoven University of Technology
Hanze University of Applied Sciences, Groningen
Tio University of Applied Sciences
HAN University of Applied Sciences
Delft University of Technology
Fontys University of Applied Sciences
Saxion University of Applied Sciences
NHL Stenden University of Applied Sciences
Aeres University of Applied Sciences
ArtEZ University of the Arts
Breda University of Applied Sciences
KIT (Royal Tropical Institute)
HU University of Applied Sciences Utrecht
The Hague University of Applied Sciences
University of the Arts The Hague
Rotterdam University of Applied Sciences
HKU University of the Arts Utrecht
TIAS School for Business and Society
The Hague Academy of Local Governance
VHL University of Applied Sciences
HZ University of Applied Sciences

Amsterdam University of Applied Sciences
Avans University of Applied Sciences
ICRA
Inholland University of Applied Sciences
Business School Netherlands
Christian University of Applied Sciences Ede
Driestar Christian University for Teacher Education
RNTC Media Training Centre
Amsterdam University of the Arts
Gerrit Rietveld Academy
Hotelschool The Hague
MDF-Training & Consultancy
Zuyd University of Applied Sciences
Transnationale Universiteit Limburg
Design Academy Eindhoven
Global School for Entrepreneurship
HAS green academy
Nyenrode Business University
T.M.C. Asser Institute
Windesheim University of Applied Sciences
Codarts, University for the Arts
Open University (Netherlands)
Protestant Theological University
THIM University of Applied Sciences in Physiotherapy

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