The effect of housing prices on relatedness and complexity in Dutch municipalities

A research on the consequences of rising housing prices on the average internal relatedness density and economic complexity of Dutch urban municipalities between 2000 and 2008.

Colophon

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Version:	Final
Date:	09-08-2019
Institution:	Utrecht University
Master:	Human Geography
Faculty:	Geosciences
Track:	Economic geography: Business & Location

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Preface

This thesis is the final test for the master Human Geography on the University Utrecht. After a year of hard work, learning and meeting inspiring people, this thesis is the icing on the cake. The process of writing this thesis was not without a struggle. Furthermore, writing the thesis was rather challenging and interesting by implementing a wide variety of scientific fields into the thesis. This made me learn a lot about the dynamics of regional economies. Besides the implementation of theories, this research challenged me to implement relatively new ways of analyses and learning the programming language 'R'. I would like to thank miss Farinha for her help with the start-up phase of the thesis. Furthermore, I would like to thank dr. Pierre-Alexandre Balland for the feedback during the mid-term presentation. A special thanks to my final supervision prof. dr. Ron Boschma for helping me to finish this thesis.

Enjoy reading,

Rens Nijenhuis

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Abstract

Relatedness and economic complexity form a research topic in economic geography for a couple years now. What is known is that these factors enable regions to diversify their economic activities and guarantee their competitive standing (Balland et al., 2018; Farinha et al., 2019). What is less well known is how the relatedness and economic complexity is influenced by the other agglomeration characteristics. Based on combining the housing market dynamics in Dutch urban municipalities with the theories regarding regional economic development this research sheds a light on this relationship.

This research finds that increasing housing prices lead to an increase in economic complexity. This is caused by a selection process due to house prices on the region's human capital and the complexity of economic activities. Increasing housing prices also influence the relatedness, indicating that economic activities are increasingly getting more related. This finding is however relatively minor.

Keywords: Relatedness, Economic Complexity, Housing prices, Agglomeration Economics, Regional Economics, Network analysis

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Introduction

In many cities, housing markets are under pressure causing increasing rents and house prices. This increase in prices potentially flattens out the opportunities of various people to live in the city. Entering the city, but also staying in an increasingly expensive city can be challenging for the majority of people. This influences the cities social- and economic fabric, leading to a changing local urban environment.

As stated by an article of the Dutch 'Volkskrant' in April this year, this is exactly what is happening in Paris. The young (creative) working class is leaving the city due to high rents and house prices, in consequence, the population of Paris has shrunk with 60.000 people between 2011 and 2016. Due to this changing social- and economic fabric, 72% of the Parisians preferably lives outside the city (Île-de-France, 2019; Volkskrant.nl, 2019). Because of this changing business and living climate some firms seek for provincial cities in France (Volkskrant.nl, 2019).

Is the case of Paris drawing a future sketch for cities in the Netherlands? Like Paris, the Dutch housing market, especially in the bigger cities, is under heavy pressure and the market is getting more and more tight (CPB, 2019). Especially in the four biggest cities. Here the price increases are highest (CPB, 2019). It is expected that this trend will persist to at least 2021 which potentially influences population composition and business climate of the cities (CPB, 2018; CBS, 2019; Hochstenbach et al., 2019).

Building on this, the competitive standing of some cities might be under pressure. This while, countries, regions, metropolitan areas and cities are increasingly seeking to expand their economies and competitive standing. Expanding the economy within a geographical area could increase the number of jobs and/or productivity within the area. This, on his turn, provides an economic base which supports certain amenities making the area more attractive and resilient. Geographic areas, like cities and metropolitan areas, are seeking this expanding of their economic bases by: attracting or nurturing new businesses, expanding existing businesses, retaining businesses that are already located in the area and diversify their economic activities (Love et al., 1999; Moretti, 2012; Frenken et al., 2007).

Relatedness and economic complexity are proven factors which facilitate this process (Balland et al., 2018; Farinha et al., 2019). Firstly, relatedness can be described as sectors, businesses, industries and/or products that require the same knowledge and/or input (Hidalgo et al., 2018). The rate of relatedness in a geographical area therefore reflects to what extend these sectors, business, industries or products are related to each other. Thus, they potentially benefit from similar agglomeration externalities, like a shared specialized labour pool (Combes et al., 2005). Furthermore, the path of regional growth and diversification is most likely to be found in related sectors (Frenken et al., 2007). The expanding of economic activities builds on leveraging local capabilities. This occurs through diversification into related activities which strengthens the regions competitive standing (Foray et al., 2012).

The second factor, Economic complexity, consists of two major variables: diversity and ubiquity (Hidalgo et al., 2009). This diversity and ubiquity can be found in factors such as knowledge, industries or firms. The relevance of these factors rests in their ubiquity. Simpler factors reside in more economies thereby adding less value to the factors (Hausmann et al., 2014). Economies which are able to weave these relevant factors together into productive capacity are considered to be complex (Hausmann et al., 2014). This complexity is necessary for regions to hold their productive capacity, attract new economic activities and it forms a driver for economic growth (Hausman et al., 2014; Pernet, 2016).

Besides these two factors which thus influence the agglomeration of economic activities, many earlier theorists like Marshall (1890) and Jane Jacobs described this process as well. They argue that the agglomeration of economic activities creates externalities which can be exploited by firms and people (Combes et al., 2005). In the current economy, the externality of a shared (specialized) labour pool, thus human capital, is considered one of the most important (Balland et al., 2018).

It is the human capital in a city which is subject to house prices. Some researchers namely argue that social segregation, and the population composition of cities, are reflected by house prices (Berry, 2003; Hochstenbach et al., 2019). Furthermore, house prices cause an upward pressure on local salaries and wages, making it more expensive for firms to locate in the agglomeration, undercutting the competitive advantage (Moretti, 2012; Berry, 2003). The entry, exit or growth of economic activities is subject to these regional competitive advantages. In this sense, a relationship between house prices and relatedness and complexity can be expected since they are the result of the economic activities. In the current debate about the excesses of the housing market, a contribution to effects of these excesses can be of added value. Furthermore, the research aims to provide a profound piece of knowledge into the literature of regional economics. The main research question will therefore be:

"To what extent do increasing housing prices, among other factors, influence the economic complexity and relatedness of Dutch urban municipalities?"

The main research question can therefore be disaggregated into 3 sub-questions:

1. To what extent do housing prices influence the economic complexity of Dutch municipalities?
2. To what extent do housing prices influence the relatedness of Dutch municipalities?
3. What are the other factors and to what extent do they influence the relatedness and complexity of Dutch municipalities?

With help of these sub-questions an answer to the main research question can be provided. Furthermore, sub-question 3 serves a basis of general understanding of the factors that influence economic complexity and relatedness.

This research starts with a scientific and societal relevance for the subject. Secondly, the theoretical framework is presented in which a brief literature review regarding the topics of this research is given. Within this theoretical framework, the conceptual model and the hypotheses are presented in order to motivate the expected relationships between house prices and relatedness and complexity. Thirdly, the way to measure the relatedness and complexity through network analysis is clarified in the data and methodology part. Furthermore, in this part the econometric models are presented. Thereafter, the empirical results of the econometric models are presented. Lastly, a discussion and concluding remarks are added to this research.

Scientific relevance

The science of economic geography produced a substantial amount of regional concepts contributing to economic vitalization of a certain area. One of the early theorists who pointed out such a regional concept was Marshall (1890). He argued that businesses cluster to economize on the transport of goods, ideas and people. This forms the motives for economic agglomeration namely: availability of intermediate- and final goods, (technological) spillovers and labour market pooling (Combes et al., 2005). Building on this cluster theory, and also part of the early theorists, was Jane Jacobs. Both theories focus on geographical proximity as a factor for the growth of cities or areas. But where Marshall mainly focused on benefits from the proximity of homogeneous firms, Jacobs added the importance of diversity of activities that are also subject to the economies of scale due to co-location (Goerzen et al., 2013).

These complementing theories form the basis of the attractiveness of cities for firms and (potential) employees. Furthermore, since technologies and business models became more complex over time the knowledge bases of regions become more valuable (Balland et al., 2018). This complexity of knowledge, is considered spatially sticky because it is built around interpersonal contact, routines of firms and localized networks and is therefore embedded in a place, which forms a comparative advantage (Balland et al., 2018). With this, the local labour market pool is considered a key factor. The proximity of a large labour market pool namely makes it easier for firms to attract workers with the characteristics they need. Furthermore, workers are more likely to find a job that suits their skills (Combes et al., 2005). The job mobility of workers between firms, in this case, transfers tacit knowledge from firm to firm sparkling innovations and strengthening the economy (Combes et al., 2005). A condition for the transfer of tacit knowledge that can be added to the motives of economic agglomeration is network formation (Boschma, 2009). Furthermore, related variety forms a key factor in the transfer of tacit knowledge (Boschma, 2009). Also, in this case, proximity plays a crucial role.

The examples presented above are all examples of forces behind clusters and the way in which clusters strengthen themselves by attracting and nurturing economic activities and human capital (Combes et al., 2005). A key role in this is reserved for local labour pool, in other words the human capital of a certain area. It is precisely the human capital in an area that can be influenced by the housing market. House prices form namely partly the lines along which socio-economic segregation is reflected, creating homogenous areas (Berry, 2003; Hochstenbach et al., 2019). The inherent geographical precipitation of the housing market causes this spatial segregation of different groups, thus human capital (Hochstenbach et al., 2019).

Although some researchers investigated the effects of spatial segregation due to the housing market on the economic performance of certain areas (Berry, 2003; Hochstenbach et al., 2019), no research looked into effects of house prices on the forces of these agglomerations. House prices namely potentially influence the proximity of human capital, thus influencing the regional economic advantages. Furthermore, high house prices contribute to the upward pressure on local wages and saleries, which tend to undercut the competitive position of local producers and other firms (Berry, 2003).

Briefly said, there are numerous different reasons to believe that house prices potentially influence the forces of agglomeration. However, literature does not cover this part yet. Therefore, this research focusses, on the forces of house prices on economic complexity and relatedness in order to partly fill this literature gap.

Societal relevance

Regional economic vitality benefits a large part of its inhabitants. Economic vitality gives regions the opportunity to grow their economic activities, it enables its inhabitants to find jobs that suits them best and it forms a supportive basis for amenities which potentially spark productivity, innovativeness and joy. To guarantee regional economic vitality, thus guarantee economic benefits for the region's inhabitants, it is necessary for regions to stay competitive, keep developing and keep growing.

Relatedness and economic complexity enable these necessities (Balland et al., 2018; Farinha et al., 2019). Related diversified economies have numerous different advantages to the economic vitality of regions. First of all, regions with a diverse set of knowledge bases which are proximate to other sectors in which the region does not currently possess a comparative advantage tend to avoid technological or sectoral crises, have limited turndowns of sectors and recover faster from crisis events (Balland et al., 2015). Secondly, an economy with a divers related set of for instance job classes to non-existing job classes is more prone to attract new job classes (Farinha et al., 2019). Attracting new job classes and/or new sectors enables regions to grow and stay competitive. Thirdly, regions with a diverse set of related industries tend to experience faster employment growth, and more entrepreneurship (Delgado et al., 2010; Delgado et al., 2014). Lastly, related diversification also holds benefits for the employees in the area. This benefit is reflected in the possibilities of workers to find another job in the region if they are displaced due to the related activities (Hidalgo et al., 2018).

Complex economies produce more unique and sophisticated products and/or knowledge. In that way complexity adds relatively more economic value, increasing incomes (Hausmann et al., 2014). Furthermore, economic complexity can be seen as a driver for economic growth and predictor for future income (Hausmann et al., 2014). Therefore, achieving economic complexity will sustain the future competitive standing of cities, benefiting its inhabitants.

Building on these previous research outcomes, it might benefit society to research the expected relationship between house prices and relatedness and complexity.

Theoretical Framework

This part of the research aims to give a broad overview of existing literature and theories regarding regional economic development, related diversification, firm location choices and housing markets. This framework will also be used to put the results of the research in context. Firstly, the theory of economic complexity is explained, after that the research brightens up the theory of relatedness. Thirdly, the forces of agglomeration will be discussed and finally the influence of the housing market on the location decision of firms and people will be discussed.

Economic complexity

Firstly, the mechanisms of regional economies and their (potential) development is broadened. in the case of this research, this mechanism is partly explained through the theory of economic complexity. Fundamental to this theory of economic complexity is the theory of the division of labour by Adam Smith (Hidalgo and Hausmann, 2009). According to Adam Smith the wealth of a nation is related to the division of labour. With this division, people and firms specialize in numerous specific activities. As a result of that, the economic efficiency increases (Rosenberg, 1965).

Furthermore, due to specialization, a person or firm could hold a profound quantity of knowledge about for instance products or business models. This specialization potentially allows others to access a quantity of knowledge that none of us would be able to hold individually (Hausmann et al., 2014). This modern reinterpretation of the theory of the division of labour is therefore tightly connected to productive structure of a region (Hidalgo, 2009; Hausmann et al., 2014). With this productive structure in mind and, looking at findings from recent research it has become clear that what a region or country produces matters more for its economic development than how much value it attracts from these products (Hidalgo, 2009). This is true for the fact that not all products are equally sophisticated, so the future income of a country is determined by the sophistication and variety of the products they produce (Hidalgo, 2009). Therefore, this process of economic development has path dependent characteristics and is potentially limited to geographical areas.

The amount of knowledge within a geographical area is determined by its inhabitants. This amount of knowledge is not mainly determined by the amount of knowledge each individual owns. Instead, the amount of knowledge within a geographical area is in line with theory of the division of labour (Hidalgo and Hausmann, 2009). Modern interpretations about the division of labour do not only show that the inherent variety plays a crucial role in the embeddedness of knowledge in a society, furthermore the embeddedness of knowledge within a society is created by the diversity of knowledge across individuals and their ability to combine this knowledge (Hausmann et al., 2014).

A distinguishing can be made between two kinds of knowledge, namely: explicit knowledge and tacit knowledge (Hausmann et al., 2014; Howells, 2002). Explicit knowledge involves knowhow that is considered to be relatively easy transmittable in formal language by for instance instruction manuals and blueprints (Howells, 2002). Tacit knowledge on the other hand, requires time and direct experience of the knowledge in order to transmit and embed the knowledge (Hausmann et al., 2014; Howells, 2002). Most often, face-to-face interactions, procedures and informal interactions are required for mutual exchange of tacit knowledge between individuals, firms or for instance institutions (Howells, 2002). Therefore, tacit knowledge requires spatial proximity and is considered to be spatially sticky which results in knowledge specialization of regions (Lorentzen, 2008). The relatively hard transmittable process of tacit knowledge results in agglomeration of knowledge in space and constraints in the process of growth and development (Hausmann et al., 2014). This process of specialization and agglomeration of mainly tacit knowledge potentially results in differences in capabilities of regions. Capabilities in this case can be understood as chunks of embedded productive knowledge which are used to perform a certain function. The so called placed-based capabilities, can be modularized to the individual level, organization level and network level (Hausmann et al,. 2014; Balland et al., 2018). Because of the geographical precipitation of tacit knowledge and the relation with capabilities, regions also have different spectrums of capabilities.

As has been stated before, the modern interpretation of the division of labour is about the ability to combine knowledge of individuals. This perspective of network formation in the diversity of knowledge and, thereby creating combined productive knowledge is what lies on the basis of economic complexity. Markets and organizations are examples of places which allow knowledge that is held by few to be reached by many (Hausmann et al., 2014). The complexity of the economy within this network formation is created by the combination of varied knowledge and capabilities into useful embedded knowledge. Therefore, complex economies can be understood as economies who are able to weave large quantities of relevant knowledge together, through large networks of people or firms, to generate a variety of knowledge-intensive products or business models (Hausmann et al., 2014). The level of economic complexity within a geographical area determines the economic growth and development. This is true for the fact that individuals or firms are limited in their knowledge space however, interactions between them enables a society to hold and use larger amounts of embedded productive knowledge (Hausmann et al., 2014).

Relatedness

Relatedness is the second concept in clarifying regional diversification and economic development. Although relatedness does not explain the whole process of regional development, it provides science with a tool to continue working on it (Hidalgo et al., 2018). In principle, relatedness is described as products, industries or research areas that require similar knowledge or input (Hidalgo et al., 2018). Synthesizing relatedness in the view of regional diversification, it can be argued that the probability that a region enters or exits an economic activity is a function of related activities present in that location (Hidalgo et al., 2018).

This principle of relatedness potentially gives regions a window of opportunity to develop into new related products, industries or research areas. The question how and why some regions diversify and develop and other regions lock-in, forms a subject for scholars in the field of evolutionary economic geography (Boschma et al., 2017; Martin et al., 2006). The basics of this perspective lie in the regions ability to attract and create new industries, products or research areas in order to offset and destruct the declining parts of their economies, which is vital for the economic development of the region in the long run (Neffke et al., 2011). This approach relies on the assumptions of the theory of Schumpeter about creative destruction. This theory refers to the process of economic evolution in which technology and innovation create new ways of doing things which leave the old ones behind (Schumpeter, 1939). Key to this economic evolution of regions is history. Past regional products, industries, research areas and so on, setup economic structures through which opportunities and boundaries for future development are created (Farinha et al., 2019). Therefore, diversification in regions mainly occurs through the recombination and the development of pre-existing regional capabilities. To put it differently, the process of related regional diversification is subject to path-dependency (Boschma, 2017; Farinha et al., 2019).

The fact that related regional diversification is subject to path-dependency does make this process non-ubiquitous. In other words, variety is inherent to this process and it is geographically bounded (Hidalgo et al., 2018).

This view on related regional diversification is in line with the place-based capabilities introduced previously. These place-based capabilities namely shape the context of regional growth possibilities and create the regional conditions for the recombination of knowledge and ideas (Barca, 2009; Balland et al., 2018). Therefore, related regional diversification is mainly built around tacit knowledge which continuous to be embodied in networks of people (Hidalgo, 2015). Furthermore, the process of regional diversification is place-based since the flattening out of price-based forms of economic advantages due to the lowering costs of transportation, the expansion of the overall knowledge stock and the further regional division of labour (Balland et al., 2018; Hidalgo, 2018). Complex knowledge, and thereby capabilities for related regional diversification, is concentrated in a few places, which hold sources for competitive advantages for firms and regions (Balland et al., 2018).

Agglomeration economies and location choice

The clustering of people in urban spaces form the basics of urban agglomerations. The urban agglomeration effects form economic benefits. These benefits are harvested from consumption and productivity activities within a diverse, geographically concentrated, competitive and urban space. This is considered to be one of the key drivers of well-being and (economic) growth of regions in the 21ste century (Glaeser, 2011; Groot et al., 2016). These agglomeration effects are forming externalities which are a subject of study for economic geographers and other fields of study for a few decades now. The externalities, on their turn, form attractive climates for different kind of firms, investments and people (Porter., 1996; Moretti, 2012; Goerzen et al., 2013). These externalities are partly reflected in the following mechanisms.

The first mechanism of externalities in urban agglomeration economies originates from Marshall (1890). His findings highlight the roles of industry concentrations and specializations in space (Marshall, 1890; Glaeser et al., 1992). The so-called Marshallian externalities focus on the concept of geographical proximity of specialized suppliers (Goerzen et al., 2013). They cluster in space to economize on the transport of goods, services, ideas and people (labour market) (Combes et al., 2005). Clusters of industries thereby generate an asset sharing system in which innovation might be achieved. Firms are for instance, supported by specialized services of other companies like consulting, legal support, research agencies and advertising. Besides the specialized services, an extensive specialized labour market pool helps firms to target the best fitting employees and the other way around (Moretti, 2012). Considered more importantly to this innovative ecosystem are the so-called knowledge spillovers. Knowledge spillovers reflect the exchange of knowledge and ideas between individuals, firms or industries. This knowledge externalities may positively affect the ability of regionally residing firms to innovate (Glaeser et al., 1992; Van der Panne, 2004; Moretti, 2012). The knowledge spillovers within specialized industry clusters generate an engine of growth for these regions and clusters (Van der Panne, 2004). This is formulized by Glaeser et al. (1992) as MAR (Marshall-Arrow-Romer) externalities in which knowledge is considered predominately industry specific. Therefore, knowledge spillovers may arise between firms within the same geographical concentrated industry. They are supported by proximate specialized services and suppliers which potentially sparks innovation (Glaeser et al., 1992; Van der Panne, 2004).

The second mechanism through which the agglomeration externalities are reflected is formed by Jacob externalities. While both the MAR externalities and the Jacob externalities rely on the assumptions of geographical proximity and knowledge spillovers, they cannot be considered similar

(Goerzen et al., 2013). Jacobs (1969), namely argues that diversity is key to innovation. The growth of cities in this view is based on a diverse set of activities within the city that are subject to the economies of scale due to co-location (Brown et al., 2010). Firms, people and industries in this case are diversified, yet complementary to each other. Therefore, from the Jacob perspective, knowledge spillovers occur between complementary rather than similar industries because ideas developed by one industry can be applied in other industries (Van der Panne, 2004). Due to the geographical proximity that cities provide, it creates an environment in which ideas flow quickly from person to person. This exchange of potential complementary knowledge across persons, firms and industries facilitates search and experimentation in innovation (Glaeser et al., 1992; Van der Panne, 2004).

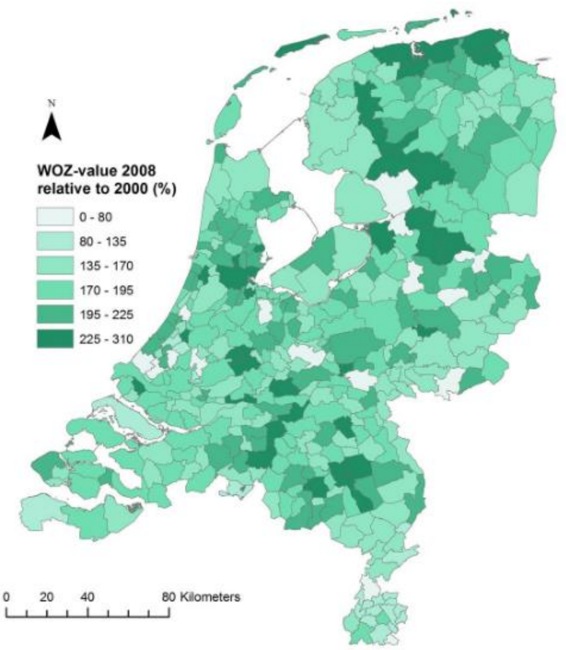
Since knowledge spillovers that potentially lead to innovation can be considered as tacit knowledge, the main part of the knowledge spillovers in both of the mechanisms is geographically sticky (Van der Panne, 2004). Therefore, knowledge spillovers occur in dense areas. Urban areas provide this density. Therefore, firms, people and industries are most likely to benefit from these externalities in urban areas.

Thirdly, competition within an urban area forms a mechanism through which agglomeration externalities are being reflected. Originating from Porter (1990), his argument suggests that, besides the previous explained mechanisms which highlight the importance of specialized and diversified knowledge and inputs, regional clusters partly grow through the motivational benefits of local competition. In this case, a cluster is defined as a group of industries connected by specialized buyer-supplier relationships or related technologies or skills (Porter, 1996). The motivational benefit of local competition might have a positive effect on innovation. Furthermore, local competition does not only affect the firm level, individuals within the labour pool also encounter motivational benefits from local competition. Thereby, potentially increasing the fit with the employer.

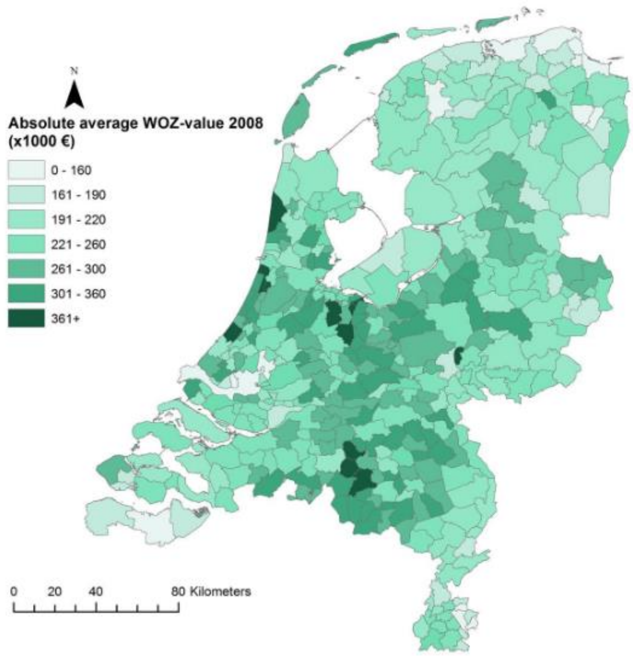
Cities, where the agglomeration externalities are present, attract firms and people for numerous different reasons. The previous explained externalities namely benefit the business climate. Firms and people can exploit these agglomeration externalities. Agglomeration economies namely have been found to improve productivity and local economic growth (Duranton et al., 2014). The local innovative environment which is thus created by the availability of specialized suppliers, goods, labour market pool and the place-based knowledge spillovers potentially benefits locally residing firms. This potential innovative advantage contributes to the firms competitive standing. Innovation, and with that the ability and capacity to develop new ideas, recombine existing knowledge assets and create new technology trajectories, in the currently rapid changing and increasingly complex economy is getting more important to stay competitive (Balland et al., 2018). Price-based forms of economic advantages on the other hand have been flattened out. Therefore, economies are increasingly understood as localized communities with their own place-based capabilities and tacit knowledge which means that geography continuous to play a role (Balland et al., 2018). This geographical aspect attracts firms and people. Concluding, related diversity in the surrounding milieu thus forms a potential source of knowledge spillovers, which can be exploited by firms and people to guarantee their competitive standing.

Housing market and location choice

In the last decades the house prices in the Netherlands rose steadily. Furthermore, relatively more of a household's income has gone to housing costs in the past few years (CBS, 2019). However, rising house prices are subject to geography, whereby the urban municipalities show not only more expensive average house prices but also a relatively larger increase in house prices (map 1; map 2).



Map 1: House prices 2008 to 2000 in Dutch municipalities (Source: CBS, 2019. Edited by author)



Map 2: Absolute average house price in Dutch municipalities (2008) (Source: CBS, 2019. Edited by Author)

House prices are particular subject to geography when it comes down to cities. Increasing demand for city living, due to agglomeration, proximity and consumer benefits in combination with inherent inelastic character of the housing market, drives up the house prices (Glaeser et al., 2001; Glaeser et al., 2005).

Furthermore, house prices are subject to marketization and financialization, resulting in an influx of capital on the housing market. This causes rising housing prices, particular in the major cities (Fernandez et al., 2016). Besides the influx of individual capital in the market, investors are increasingly diversifying their portfolio with real estate, thereby entering the Dutch housing market and increasing the house prices in major cities (Hudson-Wilson et al., 2005). In addition, the Dutch government is actively stimulating individuals to enter the buying market. In the highly financialized housing market, which the Dutch housing market is, generous mortgage lending and fiscal incentives like the Dutch mortgage-interest deductibility, are driving up the housing prices (Fernandez et al., 2016; Hochstenbach et al., 2019).

Steep increases in housing prices are leading to more costs for housing relatively to income since wages do not rise faster or evenly compared to house prices (Glaeser et al., 2001). The affordability to live in major cities therefore is under pressure. This process might have an effect on the residential selection process in cities and surrounding areas. Housing therefore can be considered central in the reproduction of social inequalities (Pikkety 2014; Savage, 2015). Those with a strong financial position can afford the more demanded places, while lower-income groups take up the rest. This leads to a spatial segregation of people because of the inherent spatial dynamics of the housing market (Hochstenbach et al., 2019). This segregation between cities and surrounding areas can be displayed through different channels. Inhabitants in cities are for instance increasingly higher educated and earn higher wages on average (Moretti, 2012). Residential location decision therefore might be considered subject to house prices.

As mentioned above, the population composition of a geographical area can partly be subscribed to the housing market. The population within the area forms the labour market within the area as well. Inhabitants form the human capital within the labour pool that provide strong determinants for a firm's innovativeness (Wixe, 2018). Also, as described earlier, the labour market pool forms one of the agglomeration externalities. Besides the human capital part, increasing house prices drive up local wages and salaries, increasing the local employment costs of firms (Berry, 2003). This influence of the housing market on the local human capital and employment costs therefore is expected to have a relationship with relatedness and economic complexity.

Merging the theories

The literature review above reflects theories about the economic development of geographical areas. The theory also reflects the way in which house prices might disrupt the human capital in and competitive standing in an area. By merging the theories, a theoretical foundation for the expected relationship between house prices and the relatedness and economic complexity of Dutch municipalities is laid. This will be highlighted in the following part.

Firstly, it is important to clarify the mechanism through which relatedness and economic complexity is influenced. Relatedness as well as economic complexity are a function of the economic activities in a certain area. These activities can change by the entry or exit of related or unrelated economic activities or by the growth or decline of related or unrelated economic activities (Balland et al., 2018; Farinha et al., 2019). The agglomeration externalities as explained above are thus a factor in the relatedness and complexity, because they create the attractiveness for certain economic activities.

Starting with relatedness, this research expects a positive effect between house prices and relatedness. If house prices increase, the costs to locate in a certain cluster and benefit from the agglomeration externalities will increase. These costs increase end up at the inhabitants and the locally residing firms. Only people who will benefit enough from the agglomeration externalities will therefore stay in the municipality. The human capital of the municipality is thus influenced by the socio-economic segregation created by house prices (Hochstenbach et al., 2019). Therefore, only the human capital related to the economic activities in the municipality stays. As a result, this human capital creates an agglomeration externality, thereby attracting economic activities that potentially benefit from their capabilities (Combes et al., 2005; Florida, 2003). The other costs of rising house prices end-up by locally residing firms. For instance, through the upward pressure on employment costs caused by house prices (Berry, 2003). Only economic activities that benefit enough from the proximity to each other and the proximity to other agglomeration externalities will stay. These are the related economic activities. Other, unrelated economic activities potentially exit the region because they do not benefit from co-locating. In that way the overall relatedness will increase.

Secondly, this research expects a positive effect between house prices and economic complexity. If the house prices increase, the costs of this increase will end up at the inhabitants of the municipality and the locally residing firms in a similar way as explained with the relatedness. The selection process of entry and exit of economic activities that follows is based on complexity. Complex economic activities add relatively more economic value to their products because of their relevance (Hausmann et al., 2014). Therefore, the more complex economic activities are, the more able they are to compensate for the increasing costs caused by housing prices. In that way, only the relatively more complex economic activities stay, and the overall economic complexity increases.

Conceptual model

The conceptual model in figure 1 provides a simplified overview of the relationship between the independent variables and the dependent variables. The validity of this model is granted by the theoretical framework. In the upcoming part these relationships will be explained.

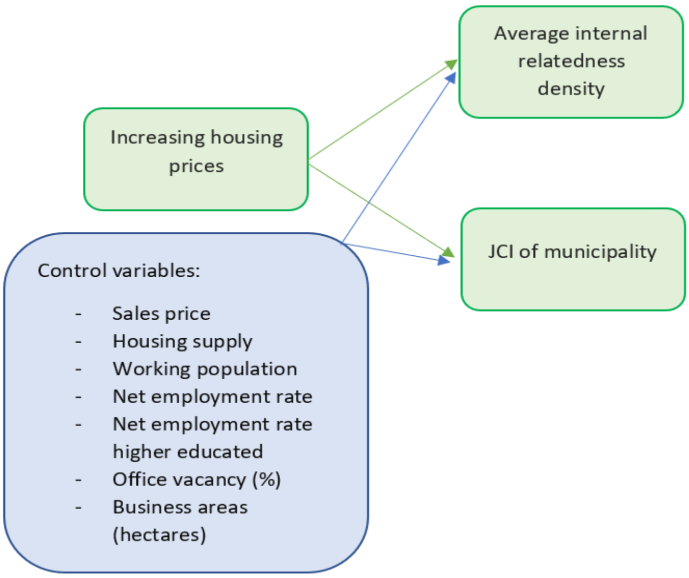


Figure 1: The conceptual model (Source: Author)

Firstly, the two dependent variables are the relatedness and the complexity. The exact terms that are used in this model will be explained further in the data and methodology part of this research.

Secondly, the influence of the control variables on the relatedness and complexity is being discussed. Also, these variables might influence the four ways in which relatedness and complexity change.

Starting with the sales *price of houses*, this variable potentially influences the dependent variables in the same way as the *house prices* (*WOZ-values*) will do, only the sale prices serve a smaller proportion of the housing market. The second control variable is the *housing supply*. The size of a region can partly be measured by the housing supply. Larger regions are on their turn more prone to attract new economic activities, thereby influencing the relatedness and complexity (Farinha et al., 2019).

Besides housing supply as a measure for size, the *working population* can be considered as a measure. As derived from the theoretical framework, an extensive working *population* forms a regional comparative advantage and agglomeration externality. In that way attracting and nurturing firms and potential employees, thus potentially influencing the relatedness and economic complexity (Moretti, 2012; Van der Panne, 2004).

In order to assess the availability of the *working population* the net *employment rate* is taken into account. This does not only indicate the availability of workers which therefore might influence the growth possibilities of economic activities, which in turn influences the relatedness and economic complexity, it might also be an indicator for economic performance. A second way to indicate the quality of the working population is by measuring the *net employment rate of the highly educated working population*. With an increasingly complexity of economic activities and the understanding that regions are more and more localized knowledge communities it is important for the competitive standing of regions to have the ability to grow with use of the human capital (Moretti, 2012; Balland et al., 2018). High *net rates of employment of the higher educated working population* potentially flattens out the opportunity to grow due a lack of people. Furthermore, it is harder to attract for instance new firms since they will have relatively more difficulties to find employees (Goerzen et al., 2013).

Besides these variables, some logical variables regarding nurturing and attracting economic activities are added in the model. These variables are the *business areas in hectares* and the *office vacancy.* Just as housing supply, the available business area in a municipality is a size measurement. Firms can only locate in the area if they have a certain amount of business areas. Besides, these areas need to be available to facilitate growth or entry of economic activities. Thereby, these variables might influence relatedness and economic complexity of regions.

Hypotheses

Following the theories from the theoretical framework and the relationships in the conceptual model, the following hypotheses are formulated. The empirical analysis will assess these hypotheses.

Hypothesis 1

The effect between house prices and relatedness is positive.

Hypothesis 2

The effect between house prices and economic complexity is positive.

Data and Methodology

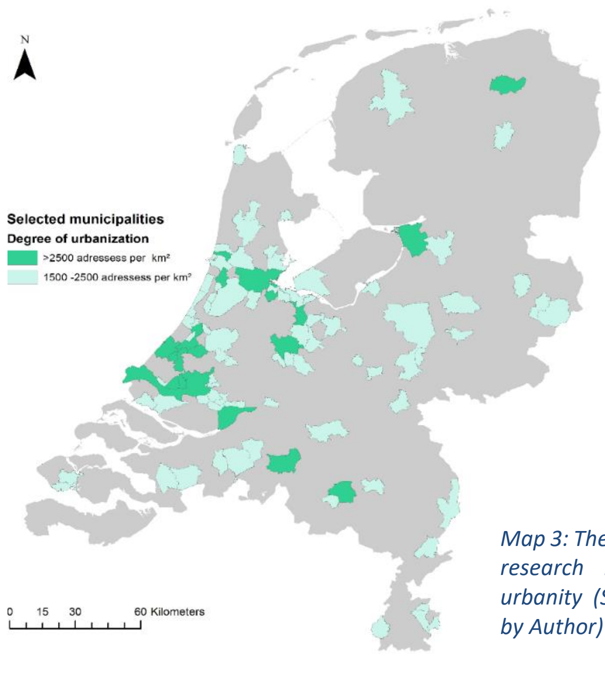
To give an answer to the research question the LISA dataset of the Netherlands is used. This dataset contains information on the firm level among which this research uses the number of employees, the municipality of registration and the third digit level working sector.

The working sectors for the firms, and thus for the employees, are classified according to the Dutch SBI-2008 codes. SBI-2008 codes, translated to “Standardized Firm Division Codes”, form a hierarchical grouping of economic activities (CBS, 2019). The first four digits are following the European NACE Rev 2 groupings which is a statistical classification of economic activities in the European community (Ec.europa.eu, 2019). This research uses the third digit level of SBI-2008 codes. The third digit level is used because it contains a more specific classification of the economic activity of a firm.

Furthermore, the number of employees per firm is used to aggregate data of the number of employees within each third digit SBI-2008 code level within the regions. The number of employees is taken because it gives a better view on the importance and added values of economic activities within a certain area. Besides this, some municipalities within the Netherlands contain many letterbox firms, which don’t add to the economic activities within the region but are only registered there for tax reasons (Fernandez et al., 2013; Lejour et al., 2013). By measuring the number of employees, these kinds of firms are being corrected for.

The regions are municipalities within the Netherlands. Because of the urban economic focus of this research and compositional differences between Dutch municipalities, only urbanized municipalities are considered. The urbanization degree is based on the urbanity measurement by the Dutch Central Bureau of Statistics (CBS). Every municipality with more than 1500 addresses per km² is considered strongly urbanized and with more than 2500 addresses per km² is considered very strongly urbanized (CBS, 2019). Furthermore, due to reclassification of municipalities over the years, some municipalities disappeared, or some fused together. Therefore, only urbanized and stable municipalities classification wise over the years are selected. Based on these values, 95 of the total number of 388 municipalities will be considered. Map 3 shows these municipalities.

The LISA dataset is available from 1996 till 2012 for this research. However, due to the availability of control variables, the period since 2000 can be used. Besides the availability of control variables, rising housing prices are of interest for this research. Therefore, only the period from 2000 until 2008 will be taken into account. Furthermore, the economic crisis in 2008 might have a profound effect on the relatedness and economic complexity of regions in the years after 2008, while these variables are not directly affected by house prices in that period.



Map 3: The municipalities used in this research based on measures of urbanity (Source: CBS, 2019, edited by Author)

Variables in the model

The variables are classified in dependent and independent variables. The two dependent variables: *economic complexity* and *average internal relatedness density* are being computed. The computation of these variables is done by using the *EconGeo Package* in *'R'* (Balland, 2017). The *economic complexity* of a municipality is calculated through the number of employees within a SBI-2008 level 3 code. Therefore, the *economic complexity* will be indicated with name *Job-class complexity* resulting in the *Job class complexity index (JCI).* A more thorough explanation of these computations can be found in the methodology part.

The main independent variable is the annual absolute house price. The Dutch *WOZ-value is* used to measure the absolute price of houses. The *WOZ-value* is based on the annual taxation of real estate by municipalities. The *WOZ-values* follow the real price of houses but are not following them one on one. However, the *WOZ-values* offer a reasonable approach of the real, real estate values (CBS, 2019). An annual average on the municipality level is taken.

Control variables

Besides the previous explained variables, some control variables are added to the analysis. These independent variables are derived from the theory in the theoretical framework. Furthermore, the control variables potentially influence the social segregation between the municipalities and the location decision of firms. The following control variables will be added to the model:

- *Sales price*: This variables reflects the average absolute sales price of houses in the municipalities. (source: opendata.cbs.nl, 2019)
- *Housing supply*: This variable reflects the number of houses within a municipality. (source: Opendata.cbs.nl, 2019)
- *Working population*: The working population is defined as the total number of people between 15 and 65 years old, who have a paid job for more than 12 hours a week or are looking for a paid job for more than 12 hours a week and are directly available for that job (CBS, 2019). (source: opendata.cbs.nl, 2019)
- *Net employment rate*: The net employment rate is formed by the percentage of the working population that is employed for more than 12 hours a week (CBS, 2019). (source: Opendata.cbs.nl)
- *Net employment rate of the highly educated*: The same as the previous variable only pre-selected on the high education level (Dutch HBO and WO education). (source: Opendata.cbs.nl, 2019)
- *Office vacancy*: This variable is defined by the vacant rentable office space as percentage of the total rentable office space. (source: PBL, 2019)
- *Business area(s)*: This variable indicates the number of hectares in each municipality that is of purpose to use for office space. It therefore gives a rough estimation for the quantitative amount of offices in an area. (source: Opendata.cbs.nl, 2019)

Relatedness, complexity and econometric models

To test the assumptions of the hypotheses, this research will follow the methodology that is applied and used in previous studies by Hidalgo *et al.* (2007), Boschma *et al*. (2014) and Balland *et al*. (2017). Before the dependent variables are constructed with the *EconGeo package* in *'R'* (Balland, P.A., 2017) a network representation of the 95 municipalities is constructed, also called the *job-space*. After that the *average internal relatedness density* and the *JCI* is computed.

Dutch municipality-job class space

Following the *product-space* framework of Hidalgo et al. (2007) the *job-space* is constructed. This structure forms a bimodal network presentation in which the structure is defined by the linkages between nodes of two different types (Borgatti, 2009). In this case the nodes are formed by the municipalities and the job-classes defined by SBI-2008 level 3 codes. A structural analysis of this bimodal network will give insights in the *average internal relatedness density* and the *JCI* of the selected municipalities. A simplified representation of this bimodal network can be found in figure 3.

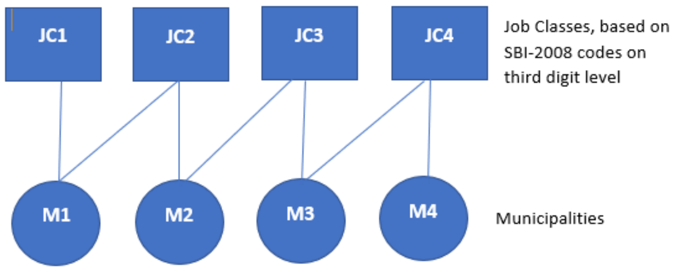


Figure 3: The simplified bimodal network of municipalities and job class specializations (Source: Author)

As explained previously this *municipality-job class* network is constructed with use of the LISA-dataset. The connections between the municipalities and job classes are constructed over time. This is influenced by entry, exit, growth or decline of the economic activities classified by SBI-2008 level 3 classes. In the case of this research, the nodes are connected to the municipalities only if the municipality holds a revealed comparative advantage (*RCA*) within a specific *job-class*. An *RCA* is taken to avoid the noise induced by negligible job-class activities within the municipalities.

To reveal the *job-classes* in which the municipalities hold an *RCA* the measurements of the 'Location Quotient' are taken. The Location Quotient of a specific job class (j) in municipality (m) is based on the number of employees (x) engaged in the job class (j) within the municipality (m) as a share of the total number of employees in the municipality, in relation to the total number of employees engaged in the job class (j) within all the taken municipalities cumulative. Resulting in the following formula:

$$LQm,j \; = \left(\frac{Xm,j}{\sum_j Xm,j}\right) / \frac{\sum_m Xm,j}{\sum m \; \sum_j Xm,j}$$

A Location Quotient higher than one means that the proportion of the number of employees engaged in a specific *job-class* is overrepresented in that municipality. Therefore, a location quotient higher than one shows that the share of employees in a specific sector in a municipality is higher than the national average share of that sector. This can therefore be considered as a degree of *specialization*, resulting in a revealed comparative advantage (CBS, 2013). The Location Quotient is calculated annually for all the sectors (*n=237*) in each of the selected municipalities (*n=95)* in the period from 2000 until 2008. Based on this measure the RCA's of job classes are assigned to the municipalities with a location quotient higher than one ($LQm, j \geq 1$).

More formally, these *RCA's* in *job-classes*, thus the *job-class specializations*, within municipalities can be presented as a network, based on a *municipality-job class* matrix. This *bimodal matrix* contains 95 municipalities and 237 job class sectors based on the third digit SBI2008-codes. Each cell in the matrix holds the number of jobs within a specific job class in a municipality. In the network, the weight of each edge is determined by the cell values because they form the input for the *RCA* measure. The nodes in the simplified network visualization (figure 4) are both formed by the *municipalities* as well as the *job-class specializations*. Following Farinha et al. (2019) for the network visualization this *municipality-job class network* does not reflect the full bimodal network but is a summary of the structure created with the *minimum spanning tree algorithm*. This algorithm creates a subset of the edges within the network.

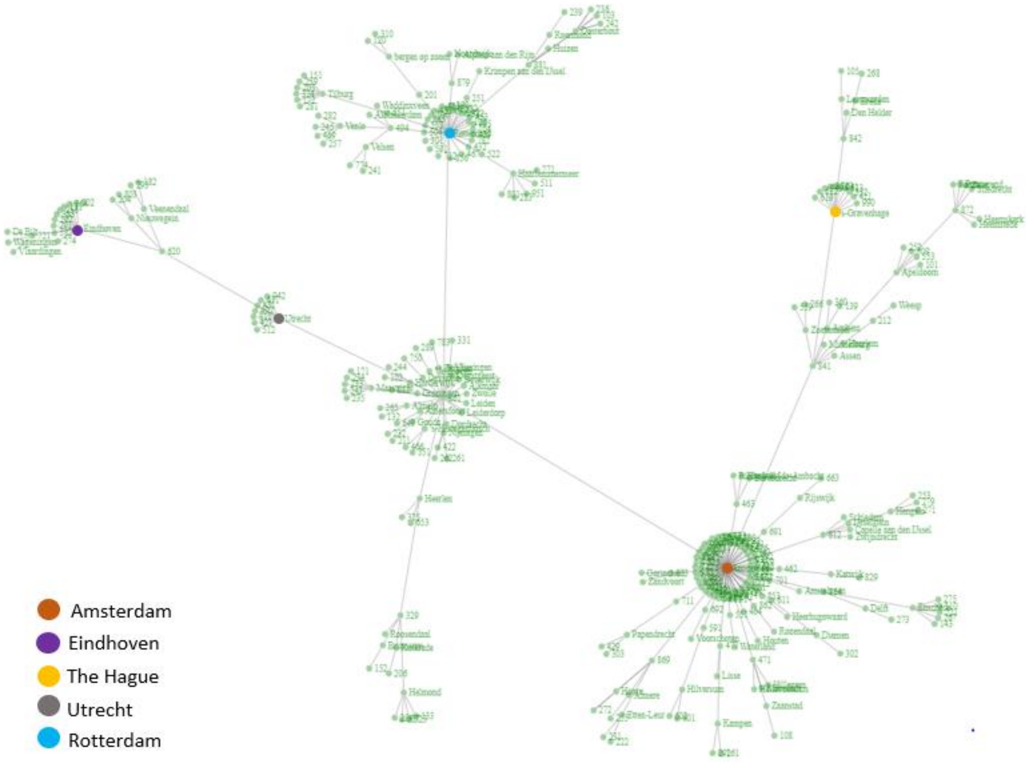


Figure 4: Simplified network representation of municipalities and job-class specializations (Source: Author)

As can be seen in network visualization (figure 4), some of the major Dutch municipalities are highlighted. What stands out for these municipalities, is that they occupy a relative central place in the network and have a relatively large diversity of *job-class specializations*. Furthermore, the network visualization reflects that some smaller municipalities occupy the more peripheral location in the network. Besides, some *job-class specializations* create a central node in de network, for instance node 861, which corresponds to hospitals and medical research and forms a *job-class specialization* for multiple municipalities (Groningen, Leiden, Maastricht). What is also interesting is that some municipalities relate to each other through a job-class specialization, like for instance the *job-class* *specialization* in code *591*, the production and distribution of movies and television programs, which connects Amsterdam with Hilversum because they both hold an *RCA* within this *job-class*.

Job-class: Relatedness density of Dutch municipalities

As stated in the theoretical framework, relatedness partly explains how and why regions diversify into new economic activities, in this case *job-class specializations*. Following the line of reasoning in this research, relatedness can be described as *job-classes* that require the same knowledge or input (Hidalgo et al., 2018). Synthesizing relatedness in the view of this research, it can be argued that the probability that a region enters or exits a *job-class specialization* is a function of related activities present in that location (Hidalgo et al., 2018).

With the construction of the *municipality-job class matrix* and *network* the foundation for this *relatedness* calculation is laid. After the calculation of the RCA's for each municipality is made a binary matrix of municipalities (m = 95) in rows and job classes (j = 237) in columns is created. In this binary *m*j* matrix a 1 indicates a revealed comparative advantage (specialization) in a job class within a municipality, a 0 is noted otherwise.

Based on this RCA matrix the geographical relatedness is calculated in '*R*' using the *EconGeo package* of Balland, P.A. (2017). The relatedness is based on the co-occurrences of RCA's within the regions. The co-occurrence function computes the number of coexisting RCA's in job classes pairs in the municipalities (Boschma et al., 2015). After the co-occurrence matrix is computed the relatedness of this co-occurrence matrix is computed.

More concretely, the geographical relatedness measure is based on the conditional-probability method developed by Van Eck and Waltman (2009). Based on a *symmetric co-occurrence job-class matrix*, the *geographical relatedness* between job-class *j* and job-class *i* is measured. In other words, given the conditional probability method, each cell in the *geographical relatedness* (*GeoRel*) *matrix* reflects the probability of a municipality (*m*) being specialized in job-class *j* given that is also specialized in job-class *i* (Farinha et al., 2019). The formula looks as follows:

$$GeoRel\ (M_{ji,}S_j, S_i, T)\ =\ M_{ji,}/(N_{co} *\ ((S_j/T)\ *\ S_i/(T-S_j) + (S_i/T)\ *\ (S_j/(T-S_i)))$$

In this formula, $M_{ji,}$ is the number of co-occurrences of job-classes *j* and *i*. $S_{j,}S_i$ are the number of co-occurrences in job-class *j* and the number of co-occurrences in job-class *i.* What was clear from the previous part, is that these co-occurrences of job-classes are based on the *RCA's* and therefore specializations of job-classes in the municipality. *T* in this formula is the sum of all municipalities job-class specializations. *M* is the sum of co-occurrences. In short, this measure of *geographical relatedness* reflects the probability of two *job-class specializations* being located in the same municipality (Farinha et al., 2019). The lowest value of *GeoRel* is zero, when for instance job-class specializations *j* and *i* are never co-located in the same municipality. However, the *GeoRel* measure has no highest value. When the *GeoRel* is higher than one, it means that the two job class specializations co-locate in the same municipality more often than by chance (Farinha et al., 2019). These are taken annually over the period from 2000 until 2008.

In order to analyze the effects of the independent variables on the *average internal relatedness density* of the selected municipalities this dependent variable needs to be computed. This dependent variable builds on the *RCA municipality-job class* matrix and the *GeoRel* matrix.

To grasp the concept of *average internal relatedness density* it firstly is necessary to clarify the concept of relatedness density. The relatedness density is operationalized by the density index (Hidalgo et al., 2007). This index, in the case of this research, measures the closeness of a jo*b-class specialization* to the other *job-class specializations* in the municipality. This measure is based on the previous *relatedness* measure.

More formally, *relatedness density* of job-class specialization *i* in municipality *m* in year *t* is computed by the relatedness of job-class specialization *i* to all other job-class specializations in the portfolio of municipality *m* in year *t*. Thereafter, divided by the sum of *job-class specialization relatedness i* to all other *job-class specializations* in all the selected municipalities in year *t*. This is multiplied by 100. Therefore, the *municipality-job class relatedness density* can be interpreted as the percentage of related *job-class specializations* found in the municipality. A simplified example will be as following: if a given job-class specialization *i* is related to 100 other job-class specializations, and if municipality *m* is specialized in 10 of those 100 job classes, then the relatedness density between job class *i* and municipality *m* will be 10% ((10/100)*100=10%). The relatedness density is thereby lower bounded by 0% and upper bounded by 100%, given the following formula:

$$RelatednessDensity_{i,m,t} = \frac{\sum_{j \in m, j \neq i} \emptyset ij}{\sum_{j \neq i} \emptyset ij} \times 100$$

The relatedness density measure forms the foundation of the *average internal relatedness density.* The measurement for this variable firstly computes the relatedness density for all the existing *job-class specializations* within each municipality with use of the above described formula. Thereafter, an average of the relatedness densities of job class specializations in the municipalities is taken. The average internal relatedness density is therefore the average percentage of related job class specializations in each municipality. For each of the municipalities (m=95) this calculation is done annually between 2000 and 2008.

Job-class: Complexity of Dutch municipalities

As stated in the theoretical framework, economic complexity can be considered as a function of diversity and ubiquity (Hausmann et al., 2014). Complex economies in that sense can be understood as economies who are able to weave relevant knowledge together, through networks of people or firms, to generate a variety of knowledge-intensive products or business models (Hausmann et al., 2014). Besides patents, technologies, number of firms etcetera, this economic complexity can be measured through the job classes located in a region. Labour pools namely hold the knowledge to generate economic activities. Furthermore, these labour pools are measured trough the firms located in the municipalities, therefore this way of measuring also reflects the networks of firms and people.

Like the average internal relatedness density, the previous constructed *municipality-job class matrix* and *network* create the foundation for the complexity measures. In the case of this research, a *job complexity index (JCI)* is computed for each of the 95 selected municipalities for each year (2000-2008). The *JCI* is measured based on the *method of reflections* developed by Hidalgo and Hausmann (2009). This method combines information about the diversity of job class specializations in the municipalities and the ubiquity of these *job-class specializations*. These calculations are done by using the *MORc* function in the *EconGeo Package* of P.A. Balland. (2017). The following formulas are used for the calculation:

$$Diversity = K_{m,0} = \sum_{j} M_{mj}$$

$$Ubiquity = K_{j,0} = \sum_{m} M_{mj}$$

In the formulas above, M_{mj} represents the *municipality-job class matrix*. $K_{m,0}$ indicates the degree of centrality of the municipality in the *municipality-job class network* based on the number of *job-class specialization*s the municipality holds. Similarly, $K_{j,0}$ reflects the degree of centrality of the *job class specializations* by looking at the number of municipalities that hold that particular *job class specialization*.

The diversity and ubiquity measures can be sequentially combined by using a series of *n* iterations. By using this way of measuring, the complexity of each municipality can be calculated, resulting in the *JCI* (Hidalgo et al., 2009). The following formulas are used:

$$JCI_{municipalities} = K_{m,n} = \frac{1}{K_{m,0}} \sum_{j} M_{mj} K_{j,n-1}$$

$$JCI_{job\ class} = K_{j,n} = \frac{1}{K_{j,0}} \sum_{j} M_{mj} K_{m,n-1}$$

In the formulas, *n* is the number of iterations used in the calculation. $K_{m,n}$ and $K_{j,n}$, respectively show the ubiquity and the diversity. The iterations used in this method yields two vectors of this ubiquity and diversity namely: $K_m = \{K_{m,0}, K_{m,1}, \ldots, K_{m,n}\}$ and $K_j = \{K_{j,0}, K_{j,1}, \ldots, K_{j,n}\}$ in which, for n=1, $K_{m,1}$ shows the average ubiquity of *job-class specializations* in a municipality and $K_{j,1}$ shows the average diversity in *job-class specializations* in a municipality.

As Hidalgo et al. (2009) shows for countries, which in this case are replaced by municipalities, even variables ($K_{m,0}$, $K_{m,2}$, $K_{m,4}, \ldots$) are generalized measures of *job-class specialization* diversification, whereas odd variables ($K_{m,1}$, $K_{m,3}$, $K_{m,5}, \ldots$) are generalized measures of job class specialization ubiquity. Each additional iteration will make the interpretation of this indicator harder however, the correlation with the complexity will increase which leads to a finer-grained estimate of the complexity (Balland et al., 2017; Ourens, 2013). The number of iterations is stopped at 20, since the *JCI* of municipalities become stable after 20 iterations.

Econometric models

In order to give an answer to the research question: "*To what extent do increasing housing prices influence the economic complexity and relatedness of Dutch urban municipalities?*", two multiple linear regression models are used. With these models an insight on the effects of the previous explained independent variables on the two dependent variables is given.

Both the models meet the assumptions of linearity, normal distribution and multicollinearity (see appendix). One thing that stands out is the collinearity between the working population and the housing supply. Logically, the more houses in a municipality, the more options to facilitate a working population. In the conclusion from the models, this collinearity will be taken into account.

The two econometric models logically flow out of the previous explained independent and dependent variables. These equations can be found below:

$$\begin{aligned} Avg.int.RelDens\ (JC\ in\ municipality) &= \beta_0 + \beta_1 WOZ - value_m + \beta_2 Sales\ price_m + \beta_3 Housing\ supply_m \\ &+ \beta_4 Working\ population_m + \beta_5 Working\ population_m \\ &+ \beta_6 Net\ employment\ rate_m + \beta_7 Net\ employment\ rate\ (H - educ)_m \\ &+ \beta_8 Office\ vacancy_m + \beta_9 \text{Business Area}_\text{m} \end{aligned}$$

$$\begin{aligned} \text{JCI (JC in municipality))} &= \beta_0 + \beta_1 WOZ - value_m + \beta_2 Sales\ price_m + \beta_3 Housing\ supply_m \\ &+ \beta_4 Working\ population_m + \beta_5 Working\ population_m \\ &+ \beta_6 Net\ employment\ rate_m + \beta_7 Net\ employment\ rate\ (H - educ)_m \\ &+ \beta_8 Office\ vacancy_m + \beta_9 \text{Business Area}_\text{m} \end{aligned}$$

The model above is built on the absolute values of both the independent and dependent variables. In order to provide a comprehensive analysis a second model is built on the percentage changes of the variables. In that way, the effect of the percentage change of independent variable *x* compared to the previous year of independent variable *x,* on the percentage change of dependent variable *y* compared to the previous year of that variable is measured. Resulting in the following equations:

$$\begin{aligned} Avg.int.RelDens.percentage.change\ (JC\ in\ municipality) &= \beta_0 + \beta_1 WOZ - value.\%change_m + \beta_2 Sales\ price.\%change_m \\ &+ \beta_3 Housing\ supply.\%change_m + \beta_4 Working\ population.\%change_m \\ &+ \beta_5 Working\ population.\%change_m + \beta_6 Net\ employment\ rate.\%change_{.m} \\ &+ \beta_7 Net\ employment\ rate\ (H - educ).\%change_m \\ &+ \beta_8 Office\ vacancy.\%change_m + \beta_9 \text{Business Area}.\%change_\text{m} \end{aligned}$$

$$\begin{aligned} JCI.percentage.change\ (JC\ in\ municipality) &= \beta_0 + \beta_1 WOZ - value.\%change_m + \beta_2 Sales\ price.\%change_m \\ &+ \beta_3 Housing\ supply.\%change_m + \beta_4 Working\ population.\%change_m \\ &+ \beta_5 Working\ population.\%change_m + \beta_6 Net\ employment\ rate.\%change_{.m} \\ &+ \beta_7 Net\ employment\ rate\ (H - educ).\%change_m \\ &+ \beta_8 Office\ vacancy.\%change_m + \beta_9 \text{Business Area}.\%change_\text{m} \end{aligned}$$

In order to get a finer-grained understanding of the effects of the independent variables on the two dependent variables four other multiple linear regression models, with a time-lag, are added. A time-lag effect is added because the WOZ-values might have a delayed effect on the *average internal relatedness density* and *JCI* of municipalities. Furthermore, the other independent variables might also have a delayed effect on the dependent variables. Besides the delayed effects, a time-lag model is added due to the measurements of the location quotient. This measurement namely compares the municipality specialization to all the municipalities. A specialization in a municipality can therefore change, not due to the changing structure of the municipality itself, but due to the overall change in ranking of the specialization (Farinha et al., 2019).

With this time-lag model, the effects of the independent variables of the previous year on the current dependent variables (*t-1*) will be calculated. In addition, a time-lag effect for two years will be added (*t-2*). This creates the following formulas in which *n* is the number of time-lagged years.

$$\begin{aligned} Avg.int.RelDens\ (JC\ in\ municipality) &= \beta_0 + \beta_1 WOZ - value_{m(t-n)} + \beta_2 Sales\ price_{m(t-1)} \\ &+ \beta_3 Housing\ supply_{m(t-n)} + \beta_4 Working\ population_{m(t-n)} \\ &+ \beta_5 Working\ population_{m(t-n)} + \beta_6 Net\ employment\ rate_{m(t-n)} \\ &+ \beta_7 Net\ employment\ rate\ (H - educ)_{m(t-n)} + \beta_8 Office\ vacancy_{m(t-n)} \\ &+ \beta_9 \text{Business Area}_{\text{m(t−n)}} \end{aligned}$$

$$\begin{aligned} \text{JCI (JC in municipality} &= \beta_0 + \beta_1 WOZ - value_{m(t-n)} + \beta_2 Sales\ price_{m(t-1)} \\ &+ \beta_3 Housing\ supply_{m(t-n)} + \beta_4 Working\ population_{m(t-n)} \\ &+ \beta_5 Working\ population_{m(t-n)} + \beta_6 Net\ employment\ rate_{m(t-n)} \\ &+ \beta_7 Net\ employment\ rate\ (H - educ)_{m(t-n)} + \beta_8 Office\ vacancy_{m(t-n)} \\ &+ \beta_9 \text{Business Area}_{\text{m(t−n)}} \end{aligned}$$

Descriptive statistics and analysis

In this part of the research the descriptive statistics for the used models and the results of the used models are being discussed. Starting with the descriptive statistics, a summary statistic quantitively describes the features of the used data. Furthermore, an indication of the house price development in the period 2000-2008 is given. Thereafter, a geographical visualization of the relatedness and complexity is presented. Lastly, the empirical results of both models are presented in table 2 and 3. These results will be explained in the following part of the analysis.

Descriptive statistics

This research will start with the summary statistics of the variables used in both models, in this case the previously explained dependent variables. These statistics can be found in table 1.

Descriptive statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
AVG int. reldens.	855	31.5	6.0	14	28	36	47
JCI	855	70.8	22.0	0.0	57.1	88.8	100.0
WOZ-Value	855	163.0	64.5	43	117	201	509
Sales price	855	217,498.3	63,149.3	95,702	178,023.5	242,212.5	541,859
Housing Supply	855	39,067.9	52,687.1	601	14,169	44,647.5	387,531
Working population	855	72,545.4	89,218.8	1,184	28,122	81,002	629,569
Population density	855	1,971.2	1,201.3	51	1,097	2,739.5	6,513
Employment Rate	855	65.2	3.4	53.9	63.2	67.3	76.6
Employment Rate (H)	855	79.6	4.3	61.5	76.7	82.7	90.0
Office vacancy	855	7.0	5.8	0	2.6	10.3	31
Business Area(s)	855	356.5	576.6	0	109.5	452.8	5,468

Table 1: Descriptive statistics of the dataset used for the regression models (source: Author)

Table 1 reflects the size of the constructed dataset for the multiple linear regression models. This is an overview of the statistics of the variables. Each variable is on the municipality level added annually to the municipality resulting in 855 observations. What stands out from these statistics is that on average 31.5% of the, in the municipality located, job class specializations are geographically related (see AVGint, table 1). Secondly, the average *JCI* is 70,8 and is upper bounded by 100. Thirdly, a relatively large gap between the average WOZ-value and the average sales price potentially results in different results from the econometric models.

Figure 5 shows the development of the average house prices in the municipalities. This figure (5) shows that average house price of the selected municipalities rose till 2008. After 2008 the price increase flattens out. Furthermore, the four major Dutch municipalities are plotted in the figure. They all follow roughly the same development in terms of relative increase, however the absolute house prices in Amsterdam are higher over the years.

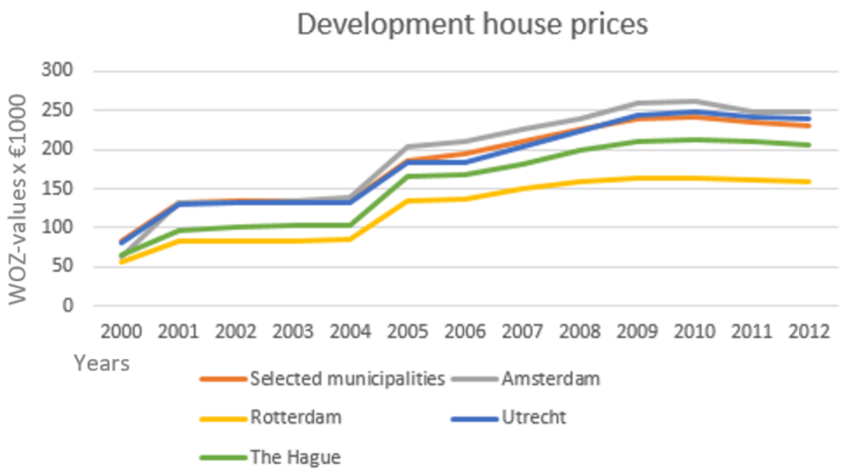
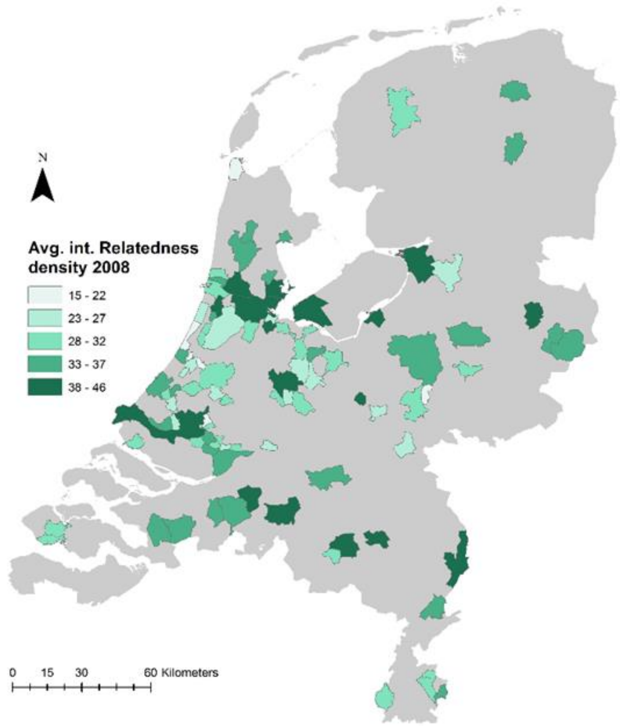


Figure 5: The average house price development in the municipalities based on WOZ-values. The average house price development of all the selected municipalities is plotted as well (Source; opendata.csb.nl, 2019; Edited by Author)

Geography of internal relatedness density

Map 4 and 5 are used in order to describe the development and geographical precipitation of the *average internal relatedness density*. In map 4, the four major Dutch municipalities are indicated. These are the largest municipalities. Although the *average internal relatedness density* increased in three of the four major municipalities, the map shows that the largest increase of average internal relatedness density is in the smaller, more peripheral municipalities. Logically, these municipalities do not have the ability to facilitate large quantities of firms and therefore *job-class specializations*. Following the literature, small municipalities are less prone to hold a large set of diverse *job-class specializations* (Farinha et al., 2019). Looking at map 5, the high values of the *average internal relatedness density* seem to be concentrated in the larger municipalities. This is in line with hypothesis 1, since in the larger municipalities like for instance Amsterdam and Utrecht, the house prices are relatively high. These maps might be a indication that hypothesis one can be confirmed.

Map 4: *The relative increase/decrease of the average internal relatedness density in the selected municipalities (Source: Author)*



Map 5: The absolute internal relatedness density of the selected municipalities in 2008 (Source: Author)

Geography of complexity

In order to visualize and give context to the development and geographical precipitation of the *JCI*, the following scatterplots and map are presented (plot 1, plot 2, map 6). The dots in the scatterplots represent the ubiquity and diversity of the selected municipalities. The four major municipalities are named. Besides the four major municipalities, the municipality with the highest level of diversity (Zaanstad) and the municipality with the highest ubiquity (Oegstgeest) are named. The diversity and ubiquity are calculated as explained in the methodology part. Here, the diversity is the number of *job-class specializations* in the municipalities. The ubiquity is the *average ubiquity* of these *job-class specializations*.

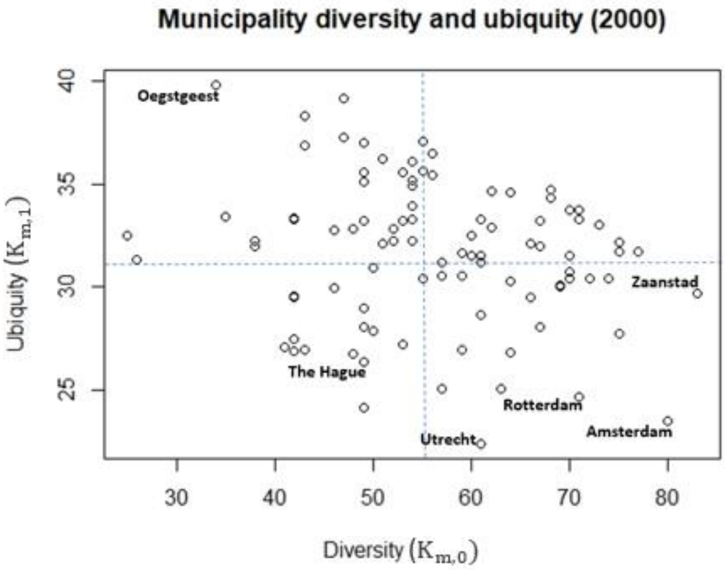
The mean of both the ubiquity and the diversity is indicated by the dotted blue lines. These lines create quadrants in which the bottom left quadrant shows municipalities with relatively few *job-class specializations* which are relatively non-ubiquitous. The Hague is one of the major municipalities present in this quadrant. If the comparison between 2000 and 2008 is made, The Hague gained some diversity and therefore almost enters the bottom right quadrant.

The top left quadrant shows municipalities with relatively ubiquitous *job-class specializations*. However, these municipalities are not so diversified. As can be seen in both scatterplots, Oegstgeest holds the most ubiquitous job class specialization(s).

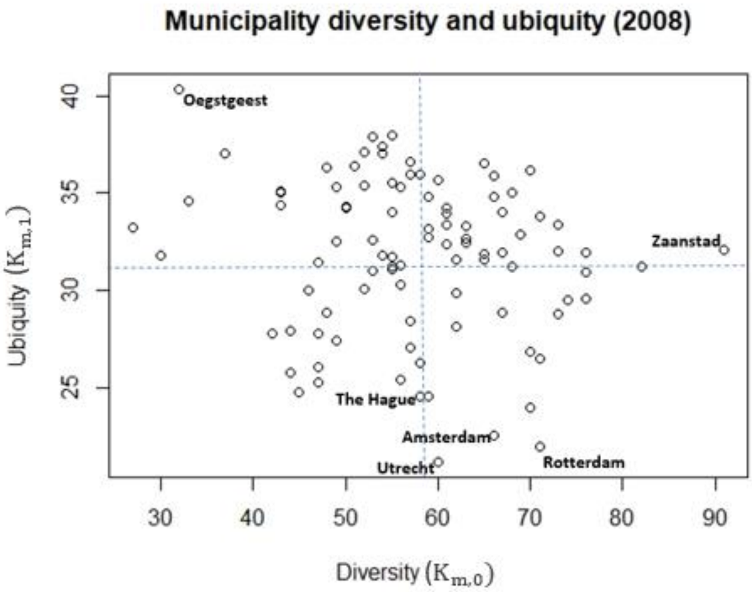
Moving to the right quadrants of the scatterplots it stands out that three of the four major municipalities are in the bottom right quadrant. This quadrant shows that these relatively large municipalities hold a relatively large set of divers *job-class specializations*. The ubiquity of *these job-class specializations* is however relatively low, indicating that these *job-class specializations* are relatively more common in the selected municipalities. This is supported by the fact that larger municipalities are more prone to attract new firms and job classes (Farinha et al., 2019).

Comparing 2000 to 2008, Amsterdam for instance lost some diversity and it gained a little bit of ubiquity. The municipality stayed however in the bottom right quadrant. On the other hand, Zaanstad moved to the top right quadrant by gaining diversity and ubiquity. This top right quadrant shows municipalities with a relatively large set of *job-class specializations* which are relatively unique. Following the formula of the *JCI*, this quadrant shows the municipalities which are most complex.

Looking at the two figures, the average ubiquity remained the same between 2000 and 2008. The mean of the diversity on the other hand has moved up between 2000 and 2008. Another thing that stands out, is that the dots itself seem to be more compact. Indicating that the diversity of *job-class specializations* is more leveled over the years. However, looking at the top right quadrants, these dots might indicate that the ubiquity moved up. This image might indicate that hypothesis 2 can be confirmed and municipalities specialize more over time. However, the empirical results will have to give a definite answer.

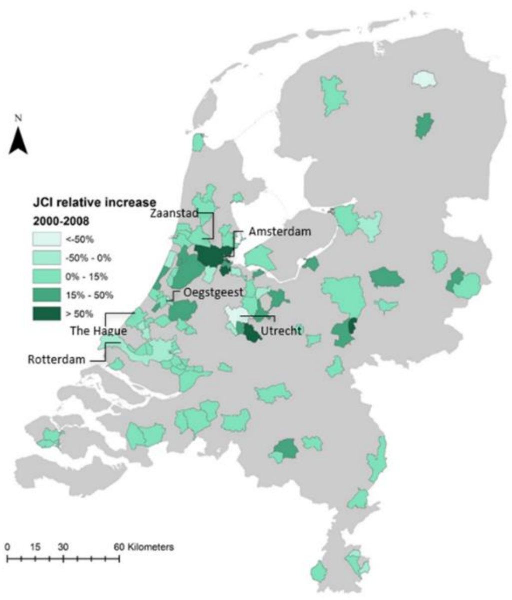


Plot 1: Scatterplot of the selected municipalities based on diversity and ubiquity in 2000 (Source: Author)

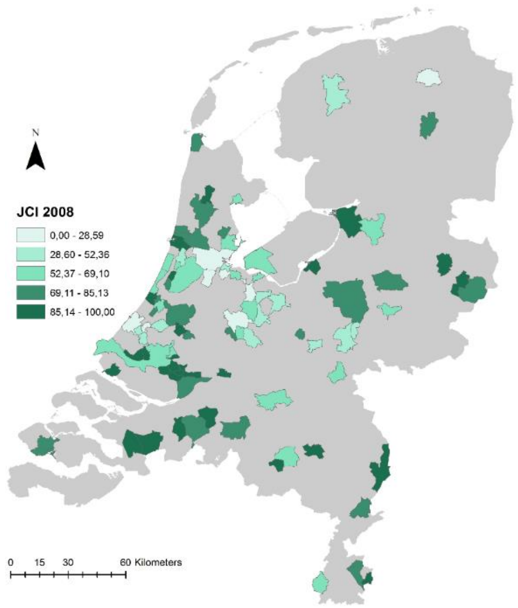


Plot 2: Scatterplot of the selected municipalities based on diversity and ubiquity in 2008 (Source: Author)

Looking at map, most municipalities gained complexity. Although all municipalities have a relatively high degree of urbanity, some municipalities gained more complexity than others. A concentration of gaining complexity municipalities can be found in the area of Amsterdam. Amsterdam and the surrounding municipalities all gained complexity over the years. Besides the metropolitan area of Amsterdam, some peripheral municipalities lost relatively much complexity. Following the theory from the theoretical framework, these municipalities are less prone to attract new economic activities (Moretti, 2012; Farinha et al., 2019). Therefore, the diversity potentially levels or decreases which might decrease the *JCI*. However, it seems like the *job-class specializations* in the larger municipalities more frequently occur, thereby decreasing the *JCI*.



Map 6: The relative increase/decrease of the JCI between 2000 and 2008 in the selected municipalities. (source: Author)



Map 7: The absolute JCI value in the selected municipalities in 2008 (source: Author).

Analysis: empirical results

In table 2 the results of the multiple linear regression models are summed up. The tables with the percentage change and the time-lag are left out. The results of these models can be found in the appendix because these tables show less significant results. Also, the adjusted R-square of both models is relatively low, given the models less explanatory power Furthermore, in the time-lagged models, the effect of the independent variables on the dependent variables weakened as timed passed.

	Dependent variables:	
	Index of complexity	Average internal relatedness density
	(1)	(2)
WOZ-value	0.083^{***}	0.007
	(0.018)	(0.006)
Sales price	-0.0002^{***}	0.00003^{***}
	(0.00002)	(0.00001)
Housing supply	0.001^{***}	-0.0002^{***}
	(0.0002)	(0.0001)
Working population	-0.001^{***}	0.0001^{***}
	(0.0001)	(0.00003)
Net employment rate	0.526^{**}	0.050
	(0.236)	(0.074)
Net employment rate (H-educated)	-0.346^{*}	0.010
	(0.179)	(0.056)
Office Vacancy	-0.200^{*}	-0.003
	(0.103)	(0.032)
Business Area's	0.018^{***}	0.001^{**}
	(0.002)	(0.001)
Constant	105.374^{***}	30.496^{***}
	(12.648)	(3.963)
Observations	855	855
R^2	0.445	0.258
Adjusted R^2	0.439	0.250
Residual Std. Error (df = 845)	16.451	5.155
F Statistic (df = 9; 845)	75.316^{***}	32.690^{***}

Note: Coefficients are statistically significant at the *p<0.1; **p<0.05 and ***p<0.01 level.

Table 2: The model without a time lag, showing the influence of the independent variables on the complexity and average internal relatedness density of job-classes in the selected municipalities (2000-2008)

Analysis: are housing prices influencing the internal relatedness density?

Table 2 shows the results of the multiple linear regression models. In this part of the research we focus on the effects of the independent variables on the *average internal relatedness density* in this table. Firstly, the adjusted R-square in the model indicates that 25% ($R^2 = 0.250$) of the variance in *average internal relatedness density* is explained by the independent variables in the regression model (Field, 2013). Hereby, special attention is paid to the *WOZ-value*.

Besides the quality of the model as a whole it stands out that the WOZ-value has a positive effect on the average internal relatedness density. Thereby, the model confirms the idea presented in hypothesis 1, however the result is not significant and hypothesis 1 is rejected. However, looking at the percentage change model in the appendix, the *WOZ-value* shows a significant positive result on the *average internal relatedness density*. A one unit increase in the percentage change of the *WOZ-value* causes the *average internal relatedness* density to increase with 2.2% ($\beta = 0{,}022$). Nonetheless, the quality and the explanatory power of the percentage change model is relatively low, so the assumptions are made based on the model in table 2.

Besides the *WOZ-value*, the *sales price* is considered. This variable does have a significant positive effect on the *average internal relatedness density*. To put this in the perspective of this research, relatedness can be influenced in four ways. The four ways are: entry or exit of related or unrelated economic activities or the growth or decline of related or unrelated economic activities. Therefore, the rising housing prices might affect one or more of these ways which influence the *average internal relatedness density*. Derived from the theoretical framework, housing prices namely potentially influence the costs to locate in a specific agglomeration of economic activities. This makes it less profitable for unrelated firms to locate in a municipality with high housing prices (Moretti, 2012). Furthermore, the labour market pool might be segregated due to house prices. Thereby changing the agglomeration externality of a shared labour market pool (Hochstenbach et al., 2019; Combes et al, 2005). However, this significant effect is relatively minor, if the sales price rises with one unit, the average internal relatedness density increases with 0,003% ($\beta = 0{,}00003$).

The largest positive effect is caused by the *net employment rate* of the municipality ($\beta = 0{,}05$), one unit increase in the net employment rate will increase the *average internal relatedness density* with 5%. Nonetheless, this effect is not significant. Other positive effects that are significant are the *working population* and the *business areas*. Respectively, a larger working population potentially allows job classes to grow because of more available employees. Moreover, given the global employment trends, more tacit and complex economic activities demand more labour (Moretti, 2012). Derived from the theoretical framework, this human capital is increasingly facilitated in larger cities which attracts firms and therefore increases the number of employees and the employment rate in the municipalities (Moretti, 2012; Wixe, 2018; Combes et al., 2001). One unit increase in the *working population* will cause a 0,01% rise in the *average internal relatedness density*. As mentioned before, the *business area(s)* also has a significant positive effect. Logically, larger quantities of business areas create more space to facilitate firms and therefore the number of employees within the *job-class specializations*. This sizebmeasurement, confirms the theory that larger municipalities are more prone to attract firms or facilitate growth (Farinha et al., 2019). In this case, this might indicate that these are related economic activities.

Furthermore, the model confirms the idea that the amount of *housing supply* negatively effects the *average internal relatedness density* of municipalities ($\beta = -0{,}002$). This contrary to the positive effect of the *working population*, which is expected to be facilitated in the housing supply. An explanation might be that larger and/or more diversified municipalities are more prone to attract new firms and with that new job-classes (Farinha et al., 2019). Following the formula of relatedness density, an increase in these unrelated activities will decrease the internal relatedness density of municipalities.

Analysis: are increasing housing prices influencing the complexity of municipalities?

In this section of the research the empirical results of the regression model of *the job complexity index* is presented. The effects of the independent variables on this complexity index will be discussed whereby special attention is paid to the WOZ-value.

Firstly, the adjusted R-square in the model indicates that 43.9% ($R^2 = 0.439$) of the variance in *job complexity index* is explained by the independent variables in the regression model (Field, 2013). This indicates that the independent variables have a relatively larger influence on the *job complexity index* of municipalities than on the *average internal relatedness density* of municipalities.

Besides the quality differences of the two models, the effects of the independent variables on the dependent variable differ as well. Foremost, the *WOZ-value* positively influences the *job complexity index* of the selected municipalities ($\beta = 0{,}083$). The significant effect shows that a one unit increase in the *WOZ-value* increases the *JCI* with 8,3%. This result is in line with the expectations from hypothesis 2. The hypothesis is therefore confirmed. Following the same line of reasoning as for the *average internal relatedness density,* increasing housing prices increases the costs for firms and people to locate in the geographical area where agglomeration benefits can be exploited (Moretti, 2012; Berry, 2003). Only related economic activities could exploit these agglomeration benefits, potentially resulting in: the exit of unrelated economic activities, the entry of related economic activities, the growth of related economic activities and/or the decline of unrelated economic activities. Furthermore, this filtering process of economic activities due to housing prices is in line with the theory of the division of labour, which is fundamental to the complexity of municipalities (Hidalgo and Hausmann, 2009). This division can be applied to municipalities, in which municipalities specialize in numerous specific economic activities which increases the economic efficiency (Rosenberg, 1965). This allows municipalities to have a profound quantity of knowledge capabilities which can be exploited by related economic activities since they need the same knowledge input (Hidalgo et al., 2018). Thereby, attracting related economic activities which potentially give municipalities a *job-class specialization.* This job-class specialization can increase the ubiquity of economic activities within a municipality, therefore influencing the *JCI*. Furthermore, the human capital of a municipality holds these place-based capabilities and is thereby attracting firms (Moretti, 2012). If house prices rise, only people who benefit from the specializations can afford to locate in a specific municipality. The human capital, and with that the place-based capabilities, therefore also specializes in a specific municipality. This in turn creates regional economic advantages and attracts firms who can exploit these capabilities (Balland et al., 2018; Moretti, 2012). In that way it is influencing the ubiquity, thus the *JCI*.

By way of contrast, the sales price of housing is negatively influencing the *JCI* of municipalities ($\beta = -0{,}0002$). Although the effect is relatively minor, one unit increase in the *sales price* decreases the *JCI* with 0,02%, the effect is significant. A potential explanation lies in the different markets the *WOZ-value* and the *sales price* serve. Where the WOZ-value influences the whole housing market, except for the public housing, the sales price only represents the buying market. This market forms a smaller proportion of the municipalities.

Other negative significant effects on the *JCI* of municipalities are formed by the *working population* ($\beta = -0{,}001$), the *net employment rate of the highly educated working population* ($\beta = -0{,}346$) and the *office vacancy* ($\beta = -0{,}200$).

The working population has an unexpected negative effect on the *JCI*. Larger municipalities, thus holding a larger number of workers, are more prone to attract new economic activities (Farinha et al., 2019). This might result in a larger diversity of *job-class specializations* in larger cities. Following the calculation for the *JCI*, this potentially results in a higher *JCI* for larger municipalities. But apparently, these job class specializations are non-ubiquitous.

The *net employment rate for higher educated workers* relatively has the largest negative effect on the *JCI* of municipalities. Although this variable is expected to attract firms (Moretti, 2012; Florida, 2003), thus increasing the *JCI,* it holds a negative effect. An explanation can be found in the ability of knowledge intensive economic activities to grow or to enter the municipalities. A high employment rate of highly educated workers namely allows little room to attract employees and/or for labour market poaching, which is negatively influencing the business climate (Combes et al., 2005; Goerzen et al., 2013).

Positive significant effects on the *JCI* of municipalities are created by the *housing supply* ($\beta = 0{,}001$), *net employment rate* ($\beta = 0{,}526$) and *the business areas* ($\beta = 0{,}018$).

Contrarily to the effect of *housing supply* on the *average internal relatedness density*, the positive effect of the *housing supply* in this case can be explained by the ability to facilitate relatively larger numbers of employees. This potentially offers more opportunities for a lager diversity of *job-class specializations.* However, the effect is relatively minor.

The *net employment rate* on the other hand has a relatively large influence on the *JCI*. Compared to the *net employment rate of highly educated workers*, this positive effect might not have to do with the business climate. The effect could be explained if we see the *net employment rate* as a factor to indicate economic growth. Growing regional economies cause related and unrelated local economic activities to grow, thereby changing the distribution of job class specializations which influences the ubiquity and diversity.

Lastly, the effect of *business areas in hectares* can potentially be explained by the ability to facilitate related firms. This, just as the *housing supply*, could increase the ubiquity and/or diversity of *job-class specializations* in the municipalities.

Discussion and concluding remarks

This chapter firstly gives an overview of the short comings in this research. These short comings are used to formulate a research agenda for the future. Secondly, an answer to the main research question is formulated. Finally, the implications of the findings will be discussed.

First of all, this research is based on the structural analysis of a *municipality-job-class matrix*. This matrix is produced annually for the period between 2000 and 2008. Because of the relative stable dependent and independent variables, it can be argued that this period is to short to draw conclusions from. However, the focus is on the effect of rising housing prices on the complexity and relatedness, which is reflected by this period.

Secondly, the *RCA* measure is taken to measure the *average internal relatedness density* and the *JCI*. By using this *RCA*, many economic activities that might be adding relatedness and economic complexity are left out (Ourens, 2013). On the other hand, negligible *job-class specializations* that induce noise in the data are left out. Thereby potentially giving more comprehensive results.

Thirdly, Farinha et al. (2019) showed that relatedness can be disaggregated based on: geography, complementary and similarity. This research only used the geographical relatedness. The other ways of measuring relatedness might have given different results.

In order to get relatively better results, future research should focus on longer time periods. Furthermore, future research should embed all dimensions of relatedness.

Looking at the sub-questions and the main question, it can be said that *house prices* have a more profound positive effect on the *economic complexity* than on the *relatedness* of the municipalities. A relative increase in house prices does however cause the relatedness to rise relatively. These results are however relatively minor and lack quality. So, even though increasing house prices cause higher local wages driving up the costs for firms and it segregates the human capital in the municipalities (Berry, 2003; Hochstenbach et al., 2019). This does not necessarily filter out the unrelated economic activities in the municipalities.

However, increasing *housing prices* do potentially influence the entry, exit or growth of related or unrelated activities in the region. This is indicated by fact that *economic complexity* increases when *housing prices* rise. Complex economic activities create higher added values and will therefore be more able to reside in more expensive regions (Hausmann et al., 2014). Less complex economic activities might not enter these regions or exit the regions as a result of rising costs. Furthermore, higher educated people are increasingly located in the more expensive regions due to numerous agglomeration externalities (Moretti, 2012; Glaeser et al., 2001). These people, which are the human capital of the region create an agglomeration externality from which especially complex economic activities can benefit. Tacit knowledge, residing in this human capital, is namely getting a more important comparative advantage in the current fast-moving market economy (Combes et al., 2005; Balland et al., 2018). The human capital, filtered by the house price, is thereby increasingly attracting and growing complex economic activities (Hochstenbach et al., 2019).

Giving an answer to the main research question: *"To what extent do increasing housing prices, among other factors, influence the economic complexity and relatedness of Dutch urban municipalities?"* it can be said that *house prices* do positively influence the *economic complexity* but do not influence the *relatedness* of the selected municipalities in The Netherlands. Besides, the *net employment* rate and *the net employment rate of the higher educated workers* have a relatively larger effect.

Building on this, this research combined the housing market dynamics with theories of regional economic development. *Relatedness* and *economic complexity* are two crucial factors in the regional economic development (Balland et al., 2018). These factors create pathways along which regions can grow and diversify their economy. Regions are therefore increasingly seeking this path of relatedness and economic complexity.

This research shows that the housing market could play a role in the development goal of regions. Especially the region's economic complexity is influenced by the housing market. Regions with increasing house prices filter human capital and complex economic activities, leaving these regions with on average more complex economic activities.

This research does thereby not suggest that regions should increase house prices in order to reach their goal of economic complexity or relatedness. Increasing house prices can namely be the outcome of demand for local amenities and job opportunities (Glaeser et al., 2005; Glaeser et al., 2001). The quality and the quantity of the regional housing supply on the other hand needs to be able to facilitate the specific human capital. This human capital is needed for the increasingly labour intensive complex economic activities (Moretti, 2012). The research only shows that the housing market does have a significant effect on the regional economic complexity in particular.

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Appendix

Econometric model assumptions

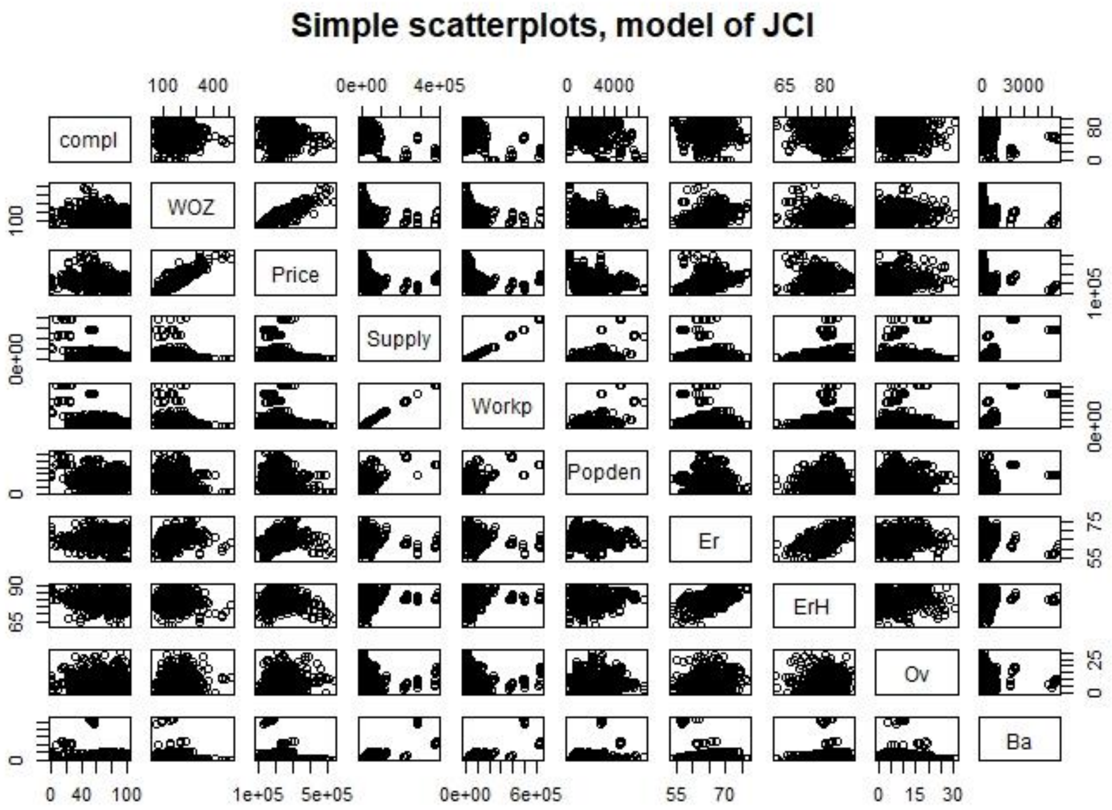

Figure 6: The linearity model for the dependent variable complexity and the independent variables from the used model.

Note: check for linearity of this model. The assumption of linearity is met by looking at the distribution of dots in the scatterplots which are indicating a linear relationship (Field, 2013).

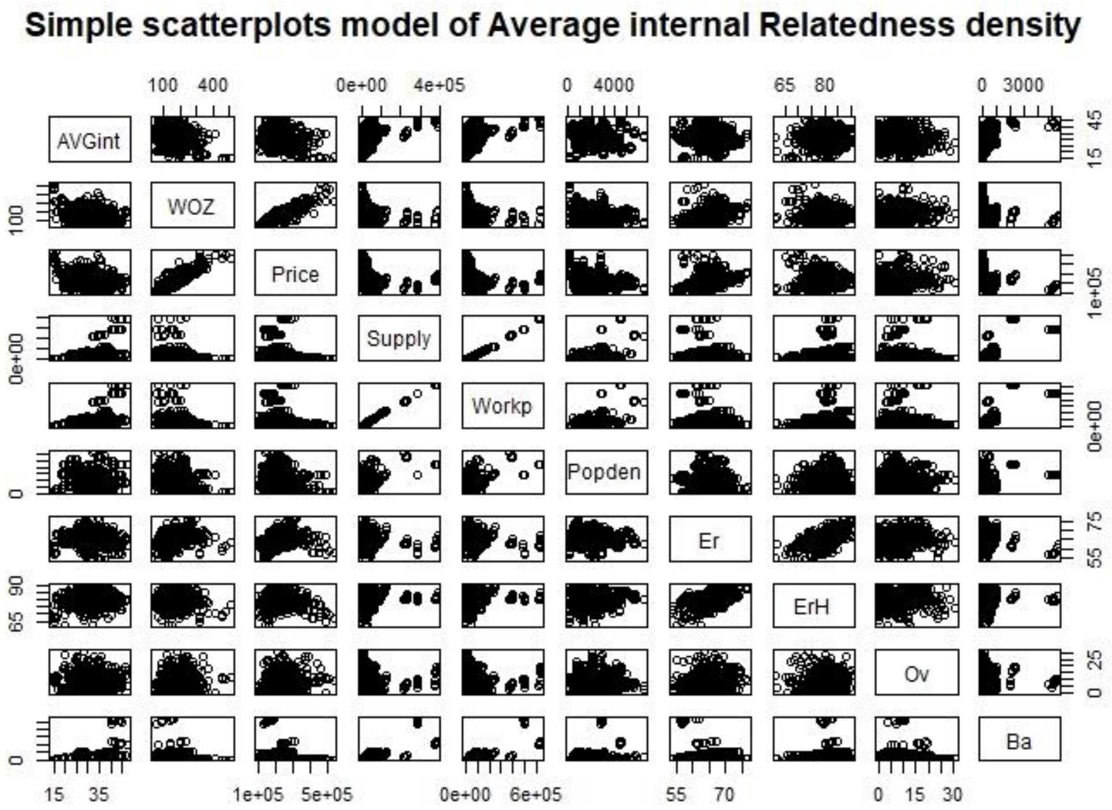

Figure 7: The linearity model for the dependent variable Average internal relatedness density and the independent variables from the used model

Note: check for linearity model 2. The assumption of linearity is met by looking at the distribution of dots in the scatterplots which are indicating a linear relationship (Field, 2013).

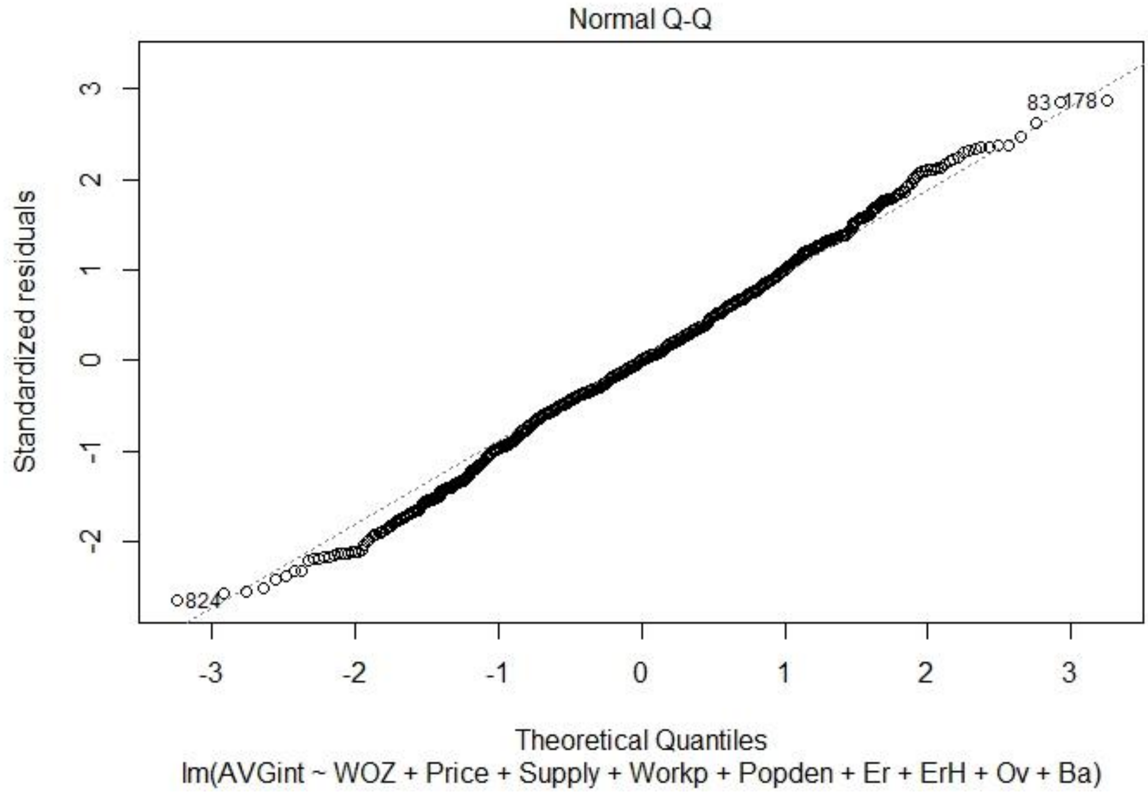

Figure 8: The normal Q-Q plot for the relatedness model indicating a normal distribution

Note: This normal Q-Q plot indicates that the second assumption of normal distribution of the residuals of the model of average internal relatedness density is met. This conclusion can be drawn from the fact that the residuals (dots) roughly follow the dotted line that indicates a normal distribution (Field, 2013).

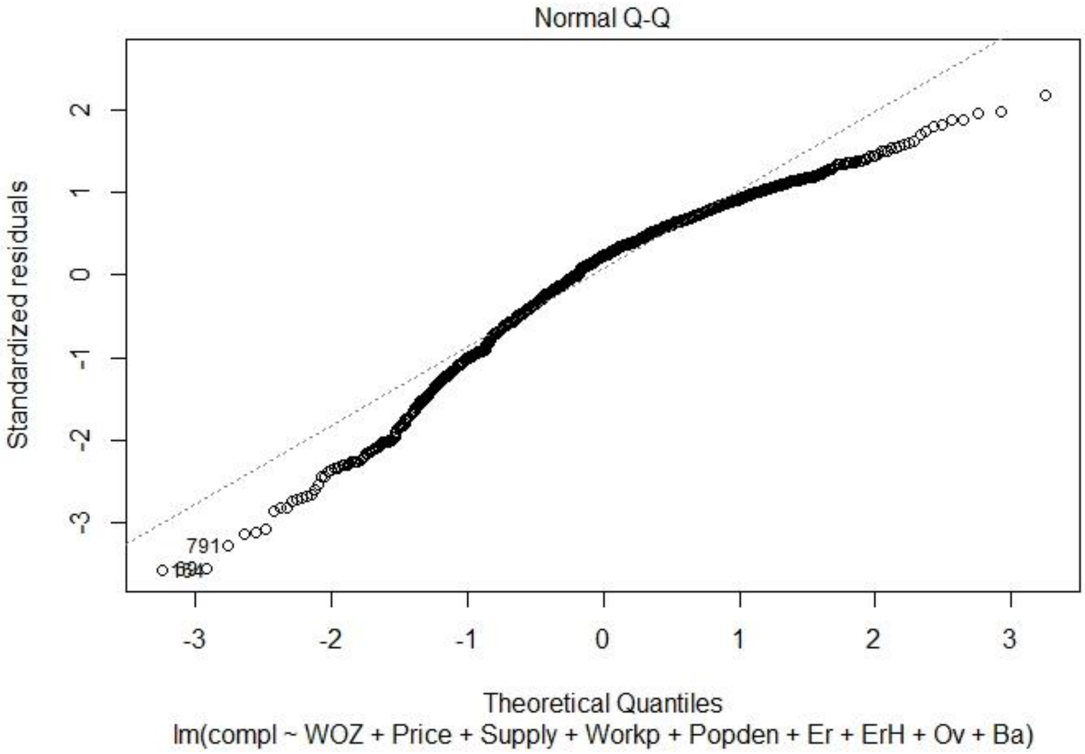

Figure 9: The normal Q-Q plot for the complexity model. Indicating a normal distribution

Note: This normal Q-Q plot indicates that the second assumption of normal distribution of the residuals of the model of average internal relatedness density is met. This conclusion can be drawn from the fact that the residuals (dots) roughly follow the dotted line that indicates a normal distribution (Field, 2013).

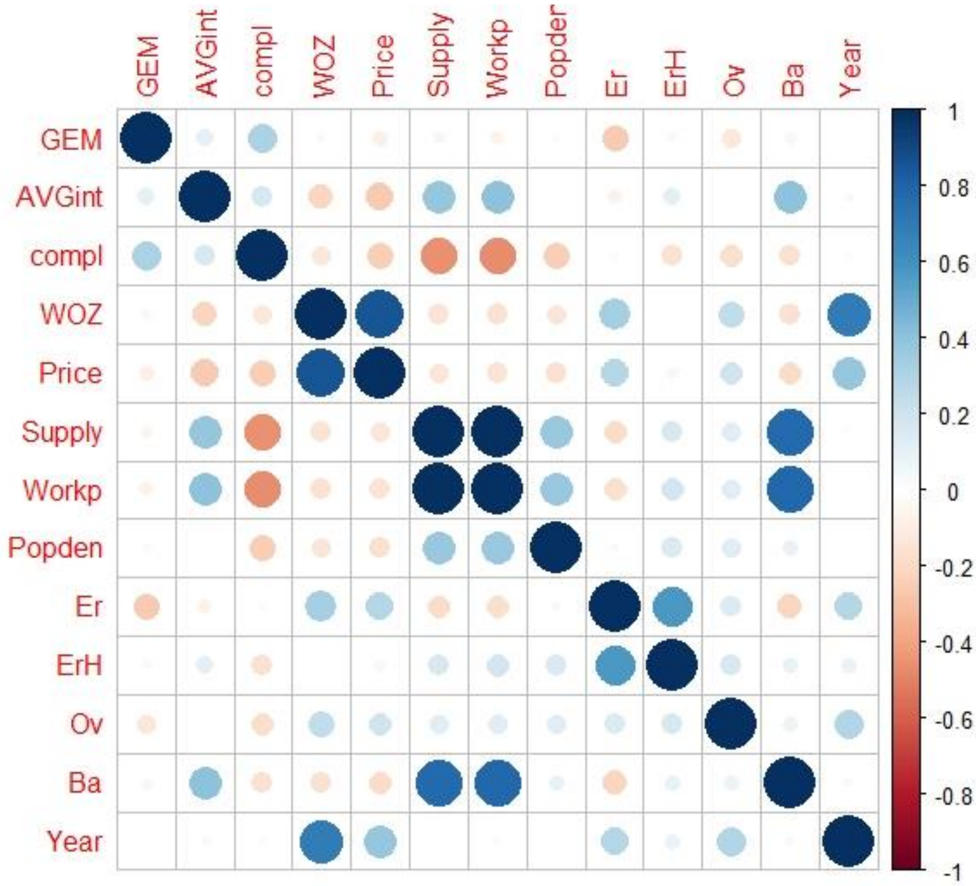

Figure 10: multicollinearity matrix of the independent variables from the used model.

Note: In this multicollinearity matrix the Pearson correlation is used. Within the matrix the size and color of the dots indicate a degree of collinearity between the independent variables. Everything between -0,8 and 0,8 can be seen as non-correlated (Field, 2013). In this matrix, you can see a correlation between the working population and the housing supply. Besides this, there is no way of multicollinearity between the variables.

Time-lag models

Regression model t-1	*Dependent variable:*	
	Complexity |	Average internal relatedness density
	(1)	(2)
WOZ-value.t-1	0.078***	0.008
	(0.019)	(0.006)
Sales price.t-1	-0.0002***	0.00003***
	(0.00002)	(0.00001)
Housing supply.t-1	0.001***	-0.0002***
	(0.0002)	(0.0001)
Working population.t-1	-0.001***	0.0001***
	(0.0001)	(0.00003)
Net employment rate.t-1	0.622**	0.034
	(0.250)	(0.080)
Net employment rate (H-educated).t-1	-0.381**	-0.004
	(0.186)	(0.059)
Office Vacancy.t-1	-0.290***	0.004
	(0.109)	(0.035)
Business Area's.t-1	0.018***	0.001**
	(0.002)	(0.001)
Constant	103.806***	32.791***
	(13.194)	(4.217)
Observations	760	760
R^2	0.456	0.257
Adjusted R^2	0.450	0.248
Residual Std. Error (df = 750)	16.115	5.150
F Statistic (df = 9; 750)	69.987***	28.797***

Note:coefficients are significant if: *p<0.1; **p<0.05; ***p<0.01

Table 3: The results from the time-lag model (t-1). Note that one year of observations disappears due to the time-lag effect . The number of observations is therefore 760 instead of 855.

(Model 2000-2008 lag t-2)

	Dependent variable:	
	Complexity | Average internal relatedness density	
	(1)	(2)
WOZ-value.t-2	0.022	0.007
	(0.021)	(0.007)
Sales price.t-2	-0.0002***	0.00003***
	(0.00002)	(0.00001)
Housing supply.t-2	0.001***	-0.0002***
	(0.0002)	(0.0001)
Working population.t-2	-0.001***	0.0001***
	(0.0001)	(0.00004)
Net employment rate.t-2	0.755***	0.051
	(0.262)	(0.086)
Net employment rate (H-educated).t-2	-0.476**	-0.018
	(0.194)	(0.064)
Office Vacancy.t-2	-0.283**	-0.003
	(0.114)	(0.038)
Business Area's.t-2	0.018***	0.001*
	(0.002)	(0.001)
Constant	104.548***	33.107***
	(13.994)	(4.596)
Observations	665	665
R^2	0.472	0.251
Adjusted R^2	0.464	0.241
Residual Std. Error (df = 655)	15.764	5.177
F Statistic (df = 9; 655)	64.931***	24.444***

Note: coefficients are significant if:
*p<0.1; **p<0.05; ***p<0.01

Table 4: The results from the time-lag model (t-2). Note that two years of observations disappear due to the time-lag effect . The number of observations is therefore 665 instead of 855.

Percentage change model

	Dependent variables:	
	Complexity |	Average internal relatedness density
	(1)	(2)
WOZ.percentage change	-0.024	0.022**
	(0.022)	(0.009)
Price percentage change	0.214**	0.057
	(0.102)	(0.040)
Housing supply percentage change	-0.875	-0.175
	(0.771)	(0.305)
Working population percentage change	0.913	0.059
	(0.716)	(0.283)
Net employment rate percentage change	-0.081***	-0.121
	(0.364)	(0.144)
Net employment rate (H-educated) percentage change	0.038	0.006
	(0.128)	(0.051)
Office Vacancy percentage change	0.005	-0.002
	(0.004)	(0.001)
Business Area's percentage change	-0.018**	0.086**
	(0.089)	(0.035)
Constant	0.019**	0.005
	(0.009)	(0.004)
Observations	760	760
R^2	0.032	0.022
Adjusted R^2	0.020	0.010
Residual Std. Error (df = 750)	0.137	0.054
F Statistic (df = 9; 750)	2.763***	1.878*

Note:
Coefficients are statistically significant at the *p<0.1; **p<0.05 and ***p<0.01 level.

Table 5: The effects of the percentage change of the independent variables on the percentage change of the complexity and average internal relatedness density of job-classes in the selected municipalities (2001-2008). Note that due to the comparison effect, the observations of the year 2000 disappears because this year has not previous reference year. The observations will therefore be 760 instead of 855.