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Explaining Population Shrinkage in Dutch regions

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Preface

This master's thesis is the last project I finish at the Erasmus University Rotterdam. I liked my time at this university. With my fellow students I followed many classes and learned a lot of new material.

I choose to write my thesis about shrinkage regions in the Netherlands. My research is focussed on the regions at the edges of the Netherlands (Groningen, Friesland, Zeeland and Limburg). The quest for a thesis subject was convenient for me. In my study Urban, Port and Transport economics my focus was on the urban economics part. I have followed several courses focused on urban economics, such as 'Urban Economics & Real Estate' and City Marketing'. Soon enough it was clear to me that there is a trend in migration from the rural area to the city. As a consequence, the countryside lost population with all due diligence. This trend also occurs in The Netherlands and is called population shrinkage. For me an excellent opportunity for further research.

Moreover, the residence of my family is located in a shrinkage area, namely Parkstad Limburg. I have seen the decay of this area myself during the last couple of years. I found out that a lot of young people moved away from this area. Besides that, the Dutch government has put money available for shrinkage regions facing population decline. Parkstad Limburg receives the highest amount of subsidy annually, meaning there is a lot of work to be done in this area.

Finally, I want to thank everyone who contributed to the completion of my education. Especially Hans Sleebos for helping me with the progress of my thesis.

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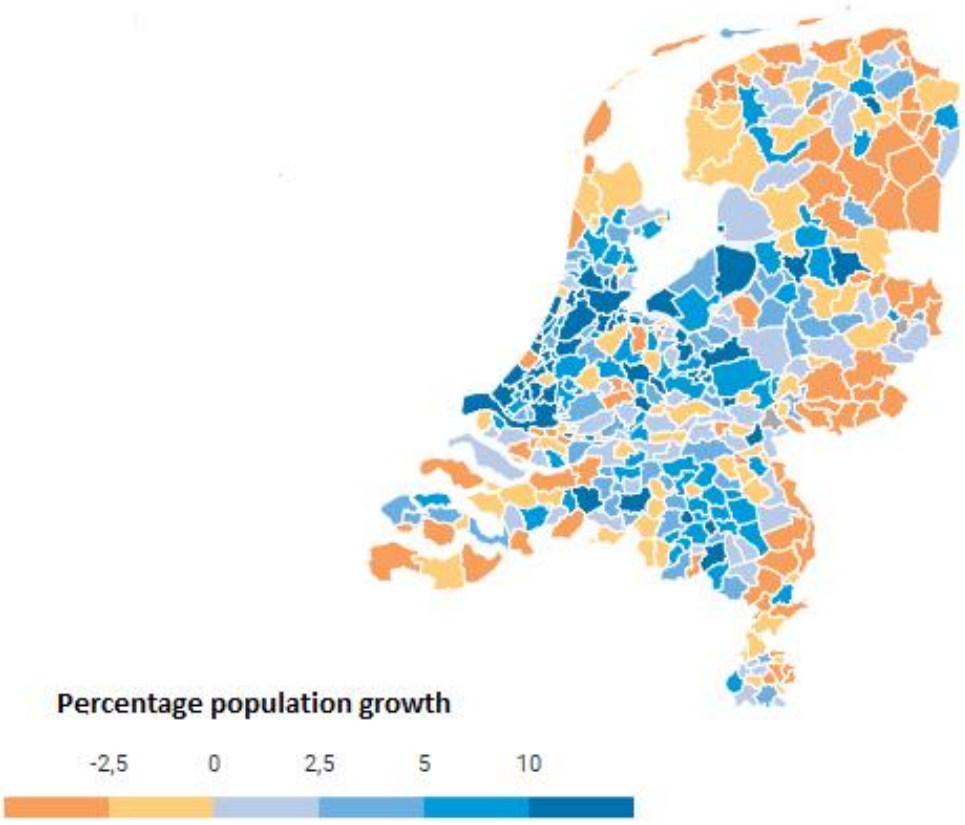
1. Introduction

1.1 Background

In recent years, one of the serious issues in the field of urban economics is depopulation. It is expected that an increasing number of regions in the Netherlands will face population decline in the upcoming decades (CBS & PLB, 2016). Although total Dutch population will continue to increase, almost 20 % of municipalities in the Netherlands will experience depopulation in 2030 (CBS & PLB, 2016). This development can be seen in figure 1.1, where a distinction has been made for the population growth per municipality in the Netherlands.

Figure 1.1: Population Growth per municipality, 2015-2030



Source*: CBS*

In general, population shrinkage is defined as a temporarily or permanently significant loss of inhabitants. Philipp Oswalt, a leading writer in the field of population shrinkage, defines shrinkage as follows: "population losses are considered to be significant if they amount to a total of at least 10% or more than 1% annually" (Oswalt & Rieniets, 2006, p. 156). Another criteria is used by the Dutch government, namely: "Regions are shrinking if they experience a population decline of at least 3% annually" (Bekkers, 2015, p. 1). This criteria is used as measurement in this study.

It can be stated that in general, population decline in a region is caused by death surplus, where the number of deaths in a region is higher than the number of new born, or emigration surplus, where more people move away in a region than settle in a region. Thus, a distinction is made between natural growth and migration. However, it is important to recognize different accelerators in a shrinking region, which can affect the resilience of a shrinkage region positively or negatively. Two of these, employment and education, will be discussed with emphasis in this thesis. Surely, sufficient employment opportunities are vital for a region to attract people. In the Netherlands it can be concluded that the number of job opportunities decreases more in shrinking regions. Especially young people will move to another region if there is no sufficient employment. My expectation is that lack of supply of education will also lead to a decline of population. These demographic changes form a risk for quality, diversity and accessibility of education.

1.1.a Social Relevance

The Dutch government acknowledges that from 2015 nine regions have to deal with population shrinkage (Bekkers, 2015). The regions considered as shrinkage regions by the Dutch government are:

- Eemsdelta (Groningen)
- Oost–Groningen (Groningen)
- De Marne (Groningen)

- Parkstad Limburg (Limburg)
- Maastricht Mergelland (Limburg)
- Westelijke Mijnstreek (Limburg)
- Zeeuws-Vlaanderen (Zeeland)
- Achterhoek (Gelderland)
- Noord-Oost Friesland (Friesland)

It is noteworthy that almost all of these regions are rural areas. It is expected that until 2040 population will decline by 16% in these regions. It is remarkable that these regions are all on the edges of the Netherlands and lie at the border with either Belgium or Germany. To reverse the negative trend the Dutch government will make a contribution of 11.2 million euros annually from 2016 until 2020 (Bekkers, 2015). The main goal for the Dutch government is to keep shrinking regions attractive for citizens to settle. The Ministry of Internal Affairs has initiated several collaborations between several provinces. An example of this is the initiating of 'Kennisplatform Demografische Transitie' (KDT). They assemble knowledge and information about shrinkage and make them available to all stakeholders. This shows the commitment of the Dutch government to find a solution for shrinking regions.

1.1.b Academic Relevance

In recent years, publications about shrinkage have increased. Since a few years, the phenomenon of shrinkage appeared on the public agenda (Heijenrath, 2011). In addition to existing literature, I want to analyze different factors of shrinking regions. To mitigate and steer the phenomenon of shrinkage it is necessary to recognize the causes. Often, population decline is associated with reduction of employment in general combined with reduction of diversity in types of work. This is accompanied by the divestment of the supply of various types of education. Therefore I have the conviction that these two factors have an effect on shrinkage.

1.2 Main Question

The aim of this thesis is to study population shrinkage in the Netherlands in general. With emphasis on the positive and/or negative effect of education and opportunities in employment on shrinkage. Therefore, my main question is:

What is the effect of education supply and employment on population shrinkage in Dutch regions?

In order to answer this main question, hypothesis are developed. These hypothesis are expectations for the results in this study, these will be discussed with the results in chapter 4. The following hypothesis are formulated:

H01: There is no relation between education supply and population shrinkage in Dutch regions

Ha: There is a relation between education supply and population shrinkage in Dutch regions

H02: There is no relation between employment and population shrinkage in Dutch regions

Ha: There is a relation between employment and population shrinkage in Dutch regions

H03: There is no interaction effect between education supply and employment in Dutch regions

Ha: There is an interaction effect between education supply and employment in Dutch regions

I assume that all these hypothesis will be rejected and a significant relation can be found between education supply and employment on population shrinkage. In addition, I expect to find an interaction effect between these two variables.

These sub questions help in order to answer the main question:

1.1 Which definition of shrinkage will be used in this research?

1.2 What are the main causes of population shrinkage according to existing literature? (§2.3)

1.3 What are the main indicators of population shrinkage according to existing literature? (§2.4)

1.4 Does variety of employment in a region have an effect on population shrinkage? (§5.1)

1.3 Research Approach

In order to research development of population in Dutch regions, a multiple regression analysis is performed by means of Stata. Both natural growth (birth surplus) and migration are included in this study. As mentioned before, population shrinkage is defined as a loss of total population. So, the best way to analyse population shrinkage is in my opinion to include both natural growth and migration. If for example, migration is excluded in the analysis, only natural growth will be researched. This way of research will gives different outcomes than using both variables in the analysis.

In order to understand why people move from one region to another, I will focus on presence of education and employment per region in the Netherlands. Other variables which can explain population development are included as control variables. These are the housing market, level of economy and the effect of the age pyramid in society. Note, only the effects of these variables on population development is researched, not the other way around.

1.3 a Data

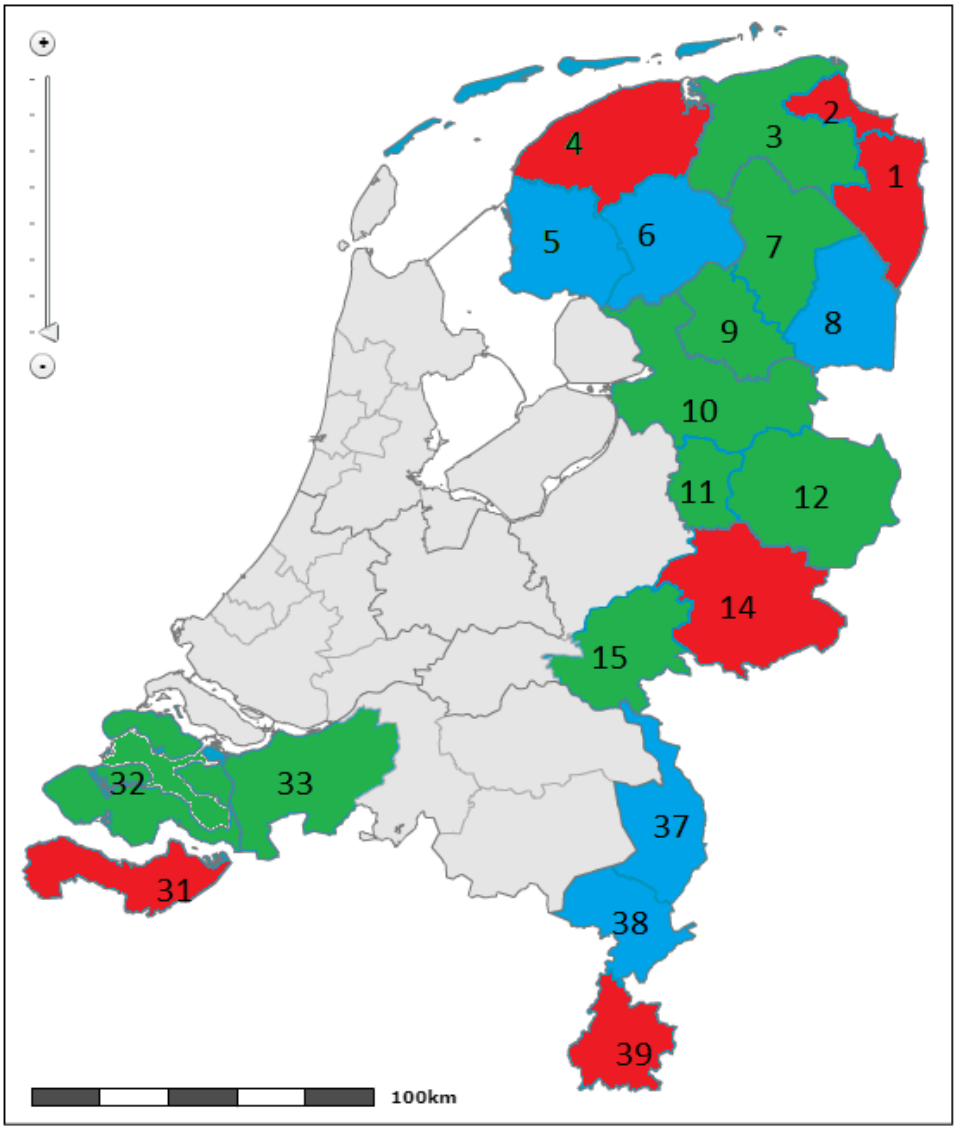
A database is made with the most important determinants of shrinkage within the period 2000-2016. The most important reason for this timespan is that population shrinkage started to occur in the Netherlands in these years. Second, some data used in this study were only available since 2000, and data after 2016 were not available yet.

1.3 b Research Area

Subsequently, the research area in this thesis will be explained. My research area is derived from the division made by the Dutch government, with some adjustments. The Dutch government makes a distinction between three different regions in The Netherlands: “krimpgebieden” (shrinkage regions), “anticipeergebieden” (anticipation regions) and “groeigebieden” (growth regions). The division of these regions is not an official one and data for these regions is not tracked. The establishment of these regions is solely based on earlier local partnerships between municipalities and regional cooperation. Sometimes these are formal partnerships (WGR regions) and sometimes informal ones. Research institutions such as **C**entraal **B**ureau voor de **S**tatistiek (CBS) and the **R**ijks**i**nstituut voor **V**olksgezondheid en **M**ilieu (RIVM) do not present statistical data for these regions. Therefore, these regions cannot be used as my research area.

To solve this problem of not finding available data for these regions, a reclassification for these regions is made. In this study, I converted the division of regions made by the Dutch government to the division that is used by the CBS, i.e. COROP regions. COROP regions are geographical boundaries that are only used for statistical research. They are in terms of scale level between municipalities and provinces. This classification is used for analytical purposes and is used to track data for instance by CBS and the RIVM. The name COROP is an abbreviation for “**Co**ordinatie Comissie **R**egionaal **O**nderzoeks**p**rogramma”. In total there are 40 COROP regions in the Netherlands, 20 of them are used in this thesis, which can be found in figure 1.2.

Figure 1.2: COROP regions used in this thesis



These regions are scattered over The Netherlands, but share a common resemblance. As can be seen in figure 1.2., all regions included in my research area lie close to the border with Germany, Belgium or both, except the regions in Friesland. Like the division of the Dutch government, the 20 COROP regions in this thesis are divided into shrinkage regions (red), anticipation regions (blue) and growth regions (green). An overview of these regions can be found in table 1.1. In the appendix all municipalities per COROP region can be found (Table 6.1).

Table 1.1: COROP regions used in thesis

Shrinkage regions	Anticipation regions	Growth regions	
01 Oost-Groningen	05 Zuidwest-Friesland	03 Overig Groningen	07 Noord-Drenthe
02 Delfzijl en omgeving	06 Zuidoost-Friesland	09 Zuid-West Drenthe	10 Noord Overijssel
04 Noord-Friesland	08 Zuidoost-Drenthe	11 Zuid-West Overijssel	12 Twente
14 Achterhoek	37 Noord-Limburg	15Arnhem/Nijmegen	32 Overig Zeeland
31 Zeeuwsch-Vlaanderen	38 Midden-Limburg	33 West-Noord-Brabant	
39 Zuid-Limburg			

Source: *CBS*

First, the shrinkage and anticipation regions in table 1.1 all match the current shrinkage areas and anticipation areas in the Netherlands. Second, growth regions are added to my research area and will be used as comparative material. The growth regions border directly to either shrinkage regions or anticipation regions used in this thesis. Third, enough regions must be included in this thesis in order to gather enough data. In general, the more observations used in a model, the more valid results a regression gives. Errors in a small sample, lead to more misinterpretation.

The remainder of this paper is: Section two will present an overview of the existing literature about population shrinkage. This is split in several parts. The first deals with the history of shrinkage, and in the second part a definition of shrinkage is given.

Furthermore, the main causes and indicators of shrinkage are outlined. Chapter three gives more information about the empirical strategy used in this thesis. Data and methodology will be explained. The next chapter, will show the results of the statistical models and discusses the implications of these results. These results are compared with the outcomes of the other studies mentioned in section two. Finally, section five gives a summary of these results. Furthermore, the implications of the results are discussed. This paper ends with the limitations of the empirical analysis and suggestions for further research.

2. Theoretical Framework

In this chapter, a literature review is given on shrinkage. This chapter is divided into different sections. First, a history overview (§2.1) is given about shrinkage. Next, a definition (§2.2) about shrinkage as used in most literature is described, as well as the main causes (§2.3) and consequences (§2.4). After that, the main indicators of shrinkage (§2.5) are given.

2.1 History of Shrinkage

In order to give a brief explanation of the phenomenon of shrinkage, an overview of history of shrinkage regions is given. This paragraph is divided into three different sections: Population loss pre-twentieth century, population loss in the twentieth century, and population loss post-twentieth century. The purpose of this paragraph is to give an overview of shrinkage through history.

Population loss pre-twentieth century

For many centuries, shrinkage regions are well-known and recognized phenomenon in urban context. Many cities faced depopulation already in pre-industrial times. Locations where people settled always known a variety of prosperous periods and diminishing periods. For instance, proceedings in catastrophes, epidemics, or wars can be a threat for regions to shrink (Oswalt & Rieniets, 2006). Declining population can also be caused by other factors such as political or social changes. A change in authority in a country is often accompanied by lot of chaos and relocation of people.

Urban population has increased enormously in the past two centuries. Only a few percent of population located in urban areas before 1800 (Rieniets, 2009). At the beginning of the 19th century this number raised to 13%. A major factor for this increase was the rise of industrialization. This development caused many changes in the landscape of cities. Despite that industrialization led to growth of urban areas, it also

caused loss of population for other regions due to waves of out-migration of the growing middle class. Suburbs started to grow exponential because the new inhabitants wanted to settle close to their workplace (Rieniets, 2009).

Population loss in the twentieth century

Population loss was still present after the turn of the century. In the 1930's a major economic depression troubled the world economy. This crisis was named the Great Depression. The result of this was that population shifted from urban areas to the surrounding rural regions. Growth rates of cities decreased dramatically and people moved to rural towns to make sure that they could meet their basic needs by themselves.

A few decades later, economic developments led to continuation of population shrinkage. Most common cause was economic decline and at the end of the twentieth century almost half of European cities were shrinking (Haase, Rink, Grossmann, Bernt, & Mykhnenko, 2014).

Population loss post-twentieth century

The trend at the end of the twentieth century continued in the new millennium, with the result that even more cities in Europe faced population shrinkage (Turok & Mykhnenko, 2007). The theory of Rieniets (2009) suggests that decline in population will remain or even extend in regions for the upcoming years. However, it is difficult to predict future developments because populations are subjected to certain developments which can occur on regional, national and global scale(Rieniets, 2009).

Like in the beginning of the twentieth century, the world economy faced a crisis in recent years. The Great Depression is comparable with this crisis. An effect of this crisis is that people move from the suburbs to central cities. Suburbia became less popular and people left these regions. Suburbia appeared to be untenable in the field of commuting distances, land use and heating (Rieniets, 2009). Therefore, living close to the city centre

was preferred over living in the suburbs.

2.2 Definition of Shrinkage

Now that the context of population shrinkage has been given, shrinkage will be defined. Shrinkage describes more than one specific development, but the commonly used indicator is fairly simple, namely loss of population. The causes and consequences of this phenomenon are varied and noteworthy differences exist worldwide (Haase et al., 2014). This also ensures that theories about shrinkage differ from each other. There is no common accepted definition of this concept, although there are some which are commonly used.

Philipp Oswalt, who is a leading scientist in urban development, defines shrinkage as follows: “Shrinking cities are cities that have temporarily or permanently lost a significant number of their inhabitants. Population losses are considered to be significant if they amount to a total of at least 10% or more than 1% annually” (Oswalt & Rieniets, 2006, p. 156). This definition is a neutral description of shrinkage and solely population loss is used to define shrinkage.

In addition, the Dutch government uses a concise and neutral definition of shrinkage as well. They define shrinkage as: “Regions are shrinking if they experience a population decline of at least 3% annually” (Bekkers, 2015, p. 1). The first sub question in this study (*Which definition of shrinkage will be used in this research?*) is hereby answered. The research area of this study is also based on the definition used by the Dutch government. This is an important reason why this definition is chosen.

Other writers in the field of shrinkage use a wider definition. Pallagst (2008) notes that shrinkage does not only include population loss but it also suggest an economic transformation. This is already a more elaborated view of shrinkage.

As mentioned before, all definitions have in common that population loss characterizes

shrinking of a region. In the majority of older studies, even the term shrinkage itself was not used. Other words to define population loss were used more than shrinkage, for instance decay and abandonment (Haase, Bernt, Grossmann, Mykhnenko, & Rink, 2013). Recently, the term is more used within the literature of cities, and the term became a framework for a wide range of studies. This led to a contribution of studies about the causes and consequences of shrinkage. In most studies, it is explained how shrinkage has originated. To study shrinkage as a process is often lacking in literature. Shrinkage can be only researched in a specific location if theoretical explanations with historical context is given. In that way, it is easier to compare the effects of population shrinkage. Moreover, it is needed that the policy environment in which shrinkage takes place is included.

Often population loss is related to negative consequences, but it can also raise new opportunities. For example, establishment costs for entrepreneurs in the shrinkage regions can fall as a result of an increase in supply of business locations. Therefore, companies will settle more likely in these regions. After shrinkage, a new period of economic prosperity can arise. In addition, with abandonment of regions, the positive effects for natural environment become clearer.

2.3 Main causes of shrinkage

Now that a clear history and definition of shrinkage is given, an overview of the most important causes of shrinkage will be described. Shrinkage can be caused by several factors. These are for instance economic, demographic, political and other factors (Oswalt & Rieniets, 2006). These factors will be discussed below. The second sub question is answered in this paragraph (*What are the main causes of population shrinkage according to existing literature?).*

Note, studies about population shrinkage do not form a consistent outcome. Causes must be researched independently. Studies about the causes of population shrinkage were developed within different theoretical frameworks at different times and different

empirical backgrounds were used for these terminologies. Different research questions were used by various people and in a variety of contexts. The context of shrinkage can be local, regional or national. As mentioned before, in this study population shrinkage is researched in Dutch regions, in other words a national context is used to research population shrinkage.

2.3.1 Economic developments

First, the causes of population shrinkage by economic developments will be discussed. These vary from economic crisis, to suburbanization and de-industrialization.

Economic Crisis

In paragraph 2.1, the effects of an economic crisis on population development is first mentioned. In this section, this cause of population shrinkage is discussed further. A large number of cities were effected by several crisis in the first half of the twentieth century. Especially urban areas and regions in Russia felt these consequences. Starvation, due to problems in food supply, was an important reason that many Russian cities were drained during the October Revolution in 1917 (Rieniets, 2009). Because of this, population moved away to the countryside in order to survive by farming.

A decade later, the first great economic crisis occurred. A migration wave from cities to the rural areas was in progress during the Great Depression. Again, cities lost a great part of its population and housing vacancies problems occurred. However, the effects of this economic crisis was less violent than the political crisis in Russia and was mostly present in the short-term. Many politicians and planners accepted this trend, although for different reasons. These settlements were regarded as a recurrence to an agricultural lifestyle by conservative planners (Kilian, 2006).

Suburbanization

Another well-known cause for population shrinkage is suburbanization. Suburbanization is a shift in population from cities to outskirts of the city. It is the

reverse of urbanization, where population shifts from the countryside to cities. Eventually the process of suburbanization will lead to urban sprawl. Communities in these region are heavily car dependent. Since the 1980's the decrease of birth rates and increase of life expectancy accelerated the rise of suburbs. Because of this, depopulation occurred in the city center. Devaluation of the inner-city stock and densely locations in the city were reasons for migration flows to the hinterland. Combined with a decrease in new babies born, the overall population in a region is unchanged. Because of this, an increase in one area eventually will lead to a decrease in other areas.

A prominent example of suburbanization occurred in the United States. Here, the middle class moved from the deprived city towards nearby new upcoming regions. These regions are independent communities, causing less tax income for the city center. The Netherlands and other European countries, are less dependent on their own incomes. Reason for this is that municipalities receive much more financial support from the National government. Nevertheless, this financial support is determined by the number of residents (Allers & Zeilstra, 2009). In this way, shrinking regions receive less financial support, but these regions are still more resistant to shrinkage than regions in the United States.

Suburbanisation is often mentioned as an additional effect of growing welfare. Because of this increase in prosperity, the middle class can afford a house with a garden outside the city. This development in the inner city was experienced in the Randstad area, where families with children moved away from the city centre to outskirts (Bontje & Latten, 2005).

Suburbanization is often mentioned with other processes of urban development. Inspired by earlier theories, Van den Berg (1982) developed a conceptual model that distinguishes four stages of urban development. The first stage of this model was urbanization, followed by suburbanization, de-urbanization and finally re-urbanization. The first stage, urbanization, is twofold. It addresses the change of population moving

from the rural area to the city, as well as a total increase of the share of residents living in cities. In general, cities are formed in this process. Often, urbanization is compared with urban growth, but these two concepts differ from each other. An increase of the proportion in the city belongs to the term urbanization, while an increase of total population in cities refer to urban growth.

After urbanization, the process of suburbanization takes place. This stage outline the period of urbanization during industrialization. This period include urban settlement to the hinterland from the city. Also, the transmigration of services, industry and business to the edges of cities are included in this stage. In a smaller area, suburbanization directly leads to population shrinkage, but in a larger area it is only relocation of people and not decline of total population. This process leads to a shift in the urban structure of a region.

The third-phase of urban development is de-urbanization, where people move from the city to rural areas. Improvements in technology is often reason why people move. This shift is accompanied by new technology. Some employment no longer requires to commute to work, whereas people can work at home. In this phase the total population of the urban area decreases and the size of small and medium cities in the broader hinterland increases. With ongoing urbanization, growth is followed by decline, so that in this way, urban areas will be tied to population decline. For this reason, this stage is also known as counter urbanization.

Re-urbanization is the last stage of urban development in the theory developed by Van den Berg (1982). This means that people are going back into an area that they have left before. This process is often started by the government to minimise the shrinkage in the city. This process is described as gentrification. Reasons for leaving the city centre is often caused by inadequate housing, pollution and overpopulation.

De-industrialization

De-industrialization is another cause of shrinkage. After the prosperous period of industrialization, a new period of social and economic change led to the reduction or even removal of industry in a region. This process is called de-industrialization. De-industrialization particular takes place in heavy industry or manufacturing industry. Economy of these regions shift from the industry sector to the tertiary sector. New technologies and ways of communication is originated in this process and took place in the 1970's (Fishman, 2004). It is the opposite of industrialization, where wealth and population increased dramatically.

With the replacement of industry sector to the tertiary sector, the producing industry become less important. In addition, it means that sometimes there is no replacement at all, causing a loss in employment. Therefore, productivity in a region declines. Because of economic decline number of jobs are decreasing and at the same time the unemployment is increasing. The result is that work-related out migration occurred in these regions. Young people and professional labor force particularly moved out to other regions. The central functions in the cities decreases and therefore economic and demographic shrinkage is induced by de-industrialization.

2.3.2 Demographic trends

Although economic development forms an important and influencing context, population shrinkage is in most cases caused by demographic trends. Two major demographic trends are discussed in this paragraph.

Ageing

A major demographic trend which causes population shrinkage is ageing (Fluchter, 2005). This trend is influenced by development of several variables, such as birth surplus and life expectancy. Ageing is a characteristic in the developed industrialised countries. Birth rates raised exponential after the World War II period and this new generation was called the baby boom generation. This generation will reach seniority in

the upcoming years and this will result in an aged society. This will lead to a growing number of deaths (De Jong & van Duin, 2010). An aged society brings other needs such as special houses for elderly people and also raised costs for the health sector. To cover these costs the policy introduced a new law namely to increase the pension age from 65 to 67.

Dejuvenation

Another important consequence of ageing is dejuvenation, which is caused by the expiration of the baby boom generation. Dejevunation is the decrease of the proportion young people in a society caused by declining birth rates. A small number of youth cohort is left behind. Dejuvenation is a demographic phase in a country where living conditions have improved considerably. Because fewer children are born, fewer pupils are enrolled in education. This has a direct impact of the viability of schools and on specific facilities for children like kindergartens and sport clubs. This will negatively affect the need for schools and teaching staff. It can also temporarily lead to a larger supply on the labour market and thus unemployment.

Selective migration

Migration occurs for all kind of reasons and all have different influence on spatial development. However, migration of a particular group in society is called 'selective migration' (Van Nimwegen & Heering, 2009). An example of such a group is families with children looking for an attractive neighbourhood and a decent primary school. Another example of selective migration could be the search for higher education of young people, or high educated people looking for jobs (brain drain). Population composition of the society is influenced by this 'selective migration' and a diminishing labour force is caused by this migration (Van Nimwegen & Heering, 2009).

In reverse to migration, immigration results in a growth of population. A reason of this growth could be the arrival of refugees and/or migrant workers (Oswalt & Rieniets, 2006). Immigration of people, next to a rise in population, leads to major social issues.

Most severe challenge for these region is integration. Often, many migrant workers find themselves in separated residential areas, which already faces socio-economic problems. These are for instance unemployment and deprivation. Immigration can eventually lead to accumulation of social problems. Often this result in social isolation of this vulnerable group.

2.3.3 Political developments

Shrinkage can also be caused by political developments, for instance the transformation of post-socialist countries. Changes in the political and economic system proceeded rapidly. The fall of a state-directed economy can cause industrial regression and high unemployment. These developments lead to outmigration. A change of power in a country is often accompanied by a lot of chaos and relocation of people. Examples of these are coups, decolonization and democratization. The transfiguration of post-socialist economies of former Soviet Union countries is an example of this. The economies of this countries changed into capitalist systems and this heavily influenced the cities. Many old industries were unable to ensure economic viability after the fall of the iron curtain. This resulted eventually in increasing unemployment rates and de-industrialization (Oswalt & Rieniets, 2006).

2.3.4 Other factors

Most important other factors that can result in population decline are wars, epidemics and natural disasters. These factors were mainly present before the industrialization, but still occur nowadays to a lesser extent.

Wars

In general, the effect of warfare on society can take serious forms. Not only short term, but also long term. Whole cities can collapse directly or indirectly. In the twentieth century, warfare had a destructive effect on population shrinkage. The total number of deaths in warfare means a direct loss in population. Also, indirect effects of warfare can be felt in a region. For instance, when cities are conquered or isolated by a new power,

many refugees will leave the city. In particular when presence of essential necessities is failed.

With the industrialization and mechanization of warfare, the impact and total number of wars in the world advanced (Elzerman, 2010). Especially cities and regions with industrial production and factories became essential during warfare (Shaw, 2004).

In World War II, the outcome of mechanization of warfare was best visible. Several locations in a region were targeted, mainly industrial plants and military facilities, as well as urban structures, both by German and British forces. The meaning behind these attacks on urban structures was to demoralize the people and weaken the enemy's determination. Ultimately, the atomic bombs dropped in Hiroshima and Nagasaki caused the annihilation of an entire city.

After World War II, new ideas and concepts were based on building new cities. Decentralization in combination with low density was an important concept for many urban planners to build modern urban areas. The devastation caused by the war was a good reason to deal with things differently. Living conditions needed more attention in order to ensure that all insufficient conditions would be overcome.

Epidemics

Another factor that can result in population decline is the outbreak of an epidemic. This can seriously jeopardize a city or even an entire country, especially those in which unhygienic living conditions are present. The most impactful example of an epidemic is the plague. Before industrialization, several cities suffered from the "black death" and this epidemic resulted in at least 75 million deaths worldwide. A recent example of an epidemic is the ebola virus disease. A large share of those infected end up dying. Entire villages and towns in Africa were damaged by the disease.

Natural Disasters

Next to wars and epidemics, the impact of a natural disaster can be fatal. The viability of a city can come under serious pressure. Natural disasters such as floods, volcanic eruptions, and earthquakes can demolish entire cities and cause many deaths. A natural disaster, unlike a cultural disaster, usually has a natural cause and therefore is not the result of human action. This distinction is increasingly difficult to make. An example of this is global warming, partly because it is a result of human action and gives rise to more and heavier natural disasters, such as hurricanes. Many natural disasters, such as floods and extreme droughts, are currently also caused by the large scale of the changes that man makes to the natural environment.

2.4 Main indicators of shrinkage

In this section, an overview of the main indicators of shrinkage is given. This thesis attempts to explain shrinkage. Therefore all properties and recognition of shrinkage will be given. In this paragraph a distinction is made in three parts: education, employment and other variables.

2.4.1 Education

There are different effects of education on shrinkage. In regions facing shrinkage, fewer students sign up for schools (Nationaal Netwerk Bevolkingsdaling, 2011). School boards and municipalities in those regions therefore face decline on different levels. Decreasing pupils impact the school on a gradual level and on educational facilities. The quality, diversity and accessibility on these services are no longer guaranteed. Dejuvenation ensures a strong and fast decline of pupil numbers. This decline will affect the funding of schools.

Primary school, secondary school and higher education are affected different by a decrease in number of pupils. The consequences of declining pupils are most visible in in primary school. This is partly because the impact of decreasing pupils have a lagged effect on secondary and higher education. The decline has not started yet. Besides these

differences, there are also a number of universal effects of shrinkage. Smaller number of pupils means less income for all school types. Again, this effect is most serious for primary school compared to secondary school and MBO (Nationaal Netwerk Bevolkingsdaling, 2011). Fewer pupils on the other hand, do not lead to fewer costs. Only when the decrease exceeds a certain value, costs will decrease. Even in most cases, decreasing costs do not outweigh the drop in income.

In the Netherlands, there is a cancellation standard for primary schools of at least 23 pupils. Because of this legislative requirement, education is one of the sectors that will experience population decline directly. A decrease in number of pupils result in a decrease in earnings. At the same time, the costs of education remain practically the same. This financial gap ensures that shrinking schools have higher costs per pupil. This is problematic in order to maintain a certain level of educational quality, especially for small schools with little financial resources. This gap is often presented as a temporary effect. However, in regions where population shrinkage stays present, the financial gap between income and costs and the process of adaptation becomes permanent.

It is not easy for schools to predict the precise course of the expenditure in case of pupil decline and to anticipate this, because there is little experience in the Netherlands. However, within the current funding system, it is assumed that schools take care of the cost management with their own resources. The development of aging causes that the average age of the teaching staff will rise (Nationaal Netwerk Bevolkingsdaling, 2011). Normally, this leads to higher salary costs. Boards of secondary school and MBO are not compensated for this. In primary school, the average age of the teacher base is taken into account for funding. The board gets a premium if the employees have a higher average age. Educational institutions with a higher or increasing average age of staff thus have less room for staff. As a result, fewer new, younger teachers can be attracted. In the short term this leads to a lack of capacity and support for education innovations, in the long term, when this 'bulk' of older teachers retires, a teacher shortage arises.

A point of care in shrinking regions is that especially first-degree teachers (with an academic training) will flow out massively. In other words will emigrate. The share of first-class teachers is highest among (almost) pension beneficiaries. Because aging is inhibiting the growth of young talent, this means a permanent quality loss. An indirect effect of demographic changes is an administrative one and geographical scaling. The scale of school boards makes it possible to keep smaller schools open, which independently cannot survive.

Thus, shrinkage promotes collaboration between schools, but ensures on the other hand, that competition will become more intensive. When a school board A closes, than this offers an opportunity for board B to attract 'new' students. Although this mechanism can lead to quality improvement in schools, it is also not conducive to cooperation at (top) regional level. Perhaps the increased competition is the cause of higher spending on marketing and PR, where the question is whether this will benefit the primary process. A good coordination between municipalities is important, because they can look at the interests of individual school boards. Where municipalities themselves function as school boards, or where coordination is not achieved, a directing or correcting role of the province may be desirable.

The drop in pupils due to hazing and shrinkage means that the sector must prepare for a long period of adjustment, where the sector is working towards a smaller but cleverly spread number of school facilities. A second point that can lead to shrinkage is a lack of resources. Designing and planning the restructuring of education, as well as the consultation with municipalities, parents and other parties costs human capacity and money. While the income of shrinking schools is falling, for this type of investment no funds are made available by the government.

It is clear that demographic changes must lead to a contraction and a reorganization of educational institutions. This is a challenge in all shrinking regions, but in rural areas this also requires an extra effort to keep education accessible. As schools lie further

apart from each other, the need for public transport will grow. A longer travel distance also means higher costs. Education in shrinking areas thus becomes more expensive than elsewhere. That is what makes these areas not particularly attractive for parents with children. Whether this kind of mechanisms will play a role in the further aging of shrinkage areas is not yet known.

In addition to supply of education, the level of education is also an important measurement for population development. A study done by Lutz and KC (2011) show that level of education has a negative effect on population growth. Lower fertility rates is associated with female education. So, a high proportion of educated women in a society show a lower overall birth rate. This leads to a reduction in the population growth rates. Therefore, universal secondary female education has been suggested as an effective way to lower population growth in a region.

2.4.2 Employment

Between 2008 and 2015 employment has more decreased in the shrinking regions than in the rest of the Netherlands according to CBS. Even in 2013 and 2014 the number of jobs decreased while in the rest of the Netherlands jobs increased. All these regions had to deal with the same developments. In these years there was a death surplus as well as a domestic departure surplus. More people left to somewhere else than that people from other regions settled in shrinkage regions.

Population shrinkage often has consequences for the regional economy (Verwest & van Dam, 2010). Most people work close to their homes. The majority of people works within a radius of 20 kilometres from their residence (Van Roon et al., 2011). If sufficient employment is lacking in a region, a possible consequence can be that especially young people move away. Finding a job is, besides education opportunities, the most important motive for people to leave their municipality and move away (Boyle, Cooke, Halfacree, & Smith, 2001) (Feijten & Visser, 2005) (Das & de Feijter, 2009). For a company there are several advantages of being settled in a crowded area. Such as, large supply of labour

and a large market, infrastructure and economies of scale of scale.

In this thesis I want to investigate the relationship between population development and jobs. There are researches available about the interaction between population and employment. One of these researches covered the Northern provinces in the Netherlands. From this, it became clear that, effects of growth and shrinkage of employment and population are not only regional, but can extend to approximately 60 kilometres. The travel time from home to work is about 45 minutes (Hoogstra, 2013). This applies to jobs for employees, not self-employed, as well as to vacancies. Because population shrinkage goes hand in hand with ageing and rejuvenation, jobs in health care and education receive special attention. For these jobs, the presence of young people and elderly is important.

Most other literature about the complex relation between housing and jobs gives no clear and unambiguously result. Hoogstra (2013) studied different countries between 1987 and 2004 to explore the relation between housing and jobs. He concluded that results between studies and within studies differ very widely. 32% of the 300 econometric model estimates that jobs follows housing, but 28 % show that housing follows jobs. A quarter of the models notes no interaction between housing and jobs and another 15 % indicates a reciprocal relationship. This study shows that the relation between housing and jobs differs between different time periods, regions and between sectors.

In the Netherlands employment followed on housing between 1996 and 2005, but this was not true for all sectors or all regions (De Graaff, Van Oort, & Boschman, 2008). The caring employment sector (education, health care, retail trade) follows housing more than driving-adding sector and value-adding sectors like industry, business services and distribution and trade.

It turned out that there are regional differences as well. Within the Randstad, jobs

follows housing, while in the intermediary zone between de Randstad and periphery the relation is more reciprocal (CBS, 2015). So housing follows jobs and jobs follow housing. In the periphery regions, where most shrinkage regions belong to, there was hardly any relationship between jobs and housing. If there was a relation, than housing follows jobs in the periphery. De Graaff et al. (2008) suggests that the changes in number of jobs are taken care of by changes in labour participation of the population and less by migration.

Another observation about employment is that the number of jobs decreased relatively more in shrinkage regions than in the other regions of the Netherlands between 2008-2014 (CBS, 2015). Especially since 2011, the number of jobs in shrinkage regions decreased more than in other regions. In table 2.4 the average decline of employment can be seen.

Table 2.1: Increase in number of jobs between 2008-2014

Shrinkage regions	Anticipation regions	Growth regions
-5,37%	-4,47%	0,10%

Source: *CBS*

As can be seen in table 2.1, the number of jobs decreased the most in these shrinking regions. In growth regions, employment even grew albeit in a small number. In addition, data about employment shows that there are strong fluctuations from year to year and that the differences between some shrinkage regions are large. An analysis about longer time periods is needed to find out whether these developments are cyclical or structural.

Besides the number of jobs in shrinkage regions, it is also informative to compare the economic structure. At first sight the influence of industry on employment is relatively large. Of all jobs in the Netherlands, just over 10 percent fell in the industrial sector in 2008, but in the shrinkage regions it varied from 12 percent in South Limburg to almost a quarter of jobs in Delfzijl and the surrounding area. In the Achterhoek and Zeeuws-

Vlaanderen almost 1 in 5 jobs is part of the industrial sector. The sectors health and well-being are also strongly represented in shrinkage regions, although the difference with the Netherlands as a whole is somewhat smaller. As described earlier, the number of jobs in shrinkage regions decreased more than in other Dutch regions. It is important to know how this decline can be explained and in which sectors employment has fallen sharply.

In the years between 2008 and 2014, substantial shifts took place in the Netherlands in employment by industry. Generally speaking, this concerns the erosion of employment in the mostly private manufacturing industry and the growth of nursing employment, predominantly in the public sector. Employment has disappeared in construction and industry and also in specialist services. The number of jobs has increased in healthcare and to a lesser extent tourism and public administration.

2.4.3 Other variables

Besides education supply and employment, other factors can have an effect on population development. Therefore other factors should be researched as well. The main other variables are: housing stock, public amenities, income and the significance of size of a region.

Housing stock

In process of time, a clear relationship can be found between the size of housing stock in a city and its population (Glaeser & Gyourko, 2005). In essence, houses are inhabited because of demand and supply in the housing market. In general, when demand exceeds supply in a region, new houses are build. Recently, only a very limited decline in the housing market has been present in Dutch regions (RIGO Research en Advies BV, 2011). The number of inhabitants in shrinking areas will decline, with a negative side effect on the level of amenities and social life. Although, total population number can decrease in a region, the number of households can still increase in these regions. The number of households is what counts on the housing market, therefore the effects of population

shrinkage has been minimal. In addition, new houses can be constructed rapidly, but will vanish slowly.

It can be seen that the housing market in shrinkage regions is clearly more relaxed than in other parts of the country. This can be seen in the relationship between buyers and suppliers. Especially in the rental sector barely more homes are requested than offered, in Northeast Groningen this is also the case in the buying sector. The spacious housing market also manifests itself in low house prices of comparable residential properties and in the ratio between the number of dwellings and the number of households. There are also evidences of (structural) vacancy, but figures about this are fragmented and not comparable nationally.

Note, that it is difficult to talk about shrinkage and anticipation regions in general terms. There are considerable differences, not only between these regions but also within the studied regions. For example, a decrease in the number of households can already be observed at specific locations in the shrinkage regions. In some regions it is the cities that are growing, while in the rural area the population is shrinking, but this picture is not consistent. In the anticipation regions this generally applies, but in the shrinking regions a much more varied pattern can be observed.

Public Amenities

The second variable which will be focused on in this study is public amenities. A smaller number of inhabitants commonly has a direct effect on a reduced support for facilities and public amenities (Nationaal Netwerk Bevolkingsdaling, 2011). The term facilities describes the total of resources and facilities in social life that people are available to participate in. Examples include shops, public transport, cultural institutions, sports facilities, childcare, schools, libraries and healthcare institutions.

The reduced use of provisions is mainly determined by:

1. The total quantitative demographic contraction and the qualitative demographic changes within this contraction, e.g. household level and the population segmentation 0-

15 years old, 15-64 years old and 65+ years old.
2. The changing society in which the previous two develop.

There is a greater density of facilities in cities and urban areas. The accessibility of accommodations is therefore less problematic and vulnerable than in the sparsely populated rural areas. Due to the fact that an increasing number of regions shrink, the number of households will decrease in more than half of the Dutch municipalities as well. This has led to vacancy of homes and a deterioration of level of public services.

Fewer people means a smaller support base for facilities, such as shops and schools, and for community life and because socially weaker groups and older people are generally left behind, villages and urban neighborhoods are threatened with a downward spiral. The level of provisions on components has sometimes reached the critical minimum. Nevertheless, a low level of provision does not necessarily lead to an unliveable life situation. There are many examples of citizens who are able to keep a small community alive and liveable.

Furthermore, fewer users mean less support for facilities. There are simply fewer people using it. This results in less money coming in to maintain facilities. But also public services that are maintained with subsidy have to do with fewer users and / or paying members. As a consequence, facilities are being closed, services are being restricted, facilities are being transferred to neighboring villages or city centers and the sports club, fanfare, and the library are bleeding. The possibility of meeting each other in the immediate living environment decreases. As a consequence, social cohesion reduces. For those who are bound to the village or region because they cannot use a car or public transport, this can mean a reduction in quality of life. This places a part of the population in a vulnerable position.

Income

As mentioned earlier, the choice to settle in a region has many determinants. One of

these determinants might be income. With regard to the average disposable income per person and per household, figures for the period 2005-2012 are available for each COROP region at CBS. In six shrinkage areas, the average income per household increased at least as much as in the Netherlands as a whole. This also applies to the average income per household, except in the Achterhoek (Table 2.2).

Table 2.2: Population and average disposable income per household (2005-2012)

	Population	**Average disposable income per household**
Delfzijl	-6,1%	16%
Zuid-Limburg	-2,7%	15%
Oost-Groningen	-2,0%	16%
Zeeuwsch-Vlaanderen	-1,5%	16%
Achterhoek	-0,3%	14%
Zuidoost-Drenthe	-0,3%	17%
Nederland	2,6%	16%

Source: *CBS*

It seems likely that income has not a direct effect on shrinkage. However, in table 2.2 only the change of disposable income per household is given, not the absolute amount. Therefore, income is included in this thesis. Note, more income is generated through more population.

The significance of size

An important difference between the pace of growing cities is the size of the city. Smaller cities most likely grow faster than large cities in the last few decades. High prices of property and congestion are negative consequences and this causes diseconomies of scale. The expansion of these areas are limited because of decreasing former industries, physical limitations on available land and planning conditions on the periphery (Turok

& Mykhnenko, 2007). However, recent research by Turok and Mykhnenko (2007) show that the position of larger cities is improving relative to smaller cities. In this thesis, the surface of a region is included as indicator of size of region.

2.5 Main consequences of shrinkage

It is obvious that shrinkage of population is a complex issue because of the many (in) direct effects. Moreover, it is also difficult to compare them. Many processes in the urban context such as infrastructure and housing influence is affected by shrinkage (Haase et al., 2013). Examples of such processes is the culture of local residents, industrial structure and urban form (Haase et al., 2013).

Consequences of shrinkage can be divided into direct consequences and indirect consequences. First, direct consequences will be defined in this study. These consequences range from housing vacancies, to underuse of infrastructure and decreasing tax revenues (Haase et al., 2014). The indirect consequences of population shrinkage are defined as a combination of several factors. This can eventually lead to decay and abandonment of a region. The status of the region then completely changes.

For a study it must be clear if shrinkage of population is caused abruptly or effect the region for a long time. Also, it is important to know if only certain parts of regions is affected by shrinkage or an entire region. In other words shrinkage has generated different levels of impact. These can be distinguished in its extent, duration, underlying factors and tempo.

If we look at the whole inhabitation of a region we can note that shrinkage will have a different impact. Vulnerable groups will have the most difficulties to recover from these consequences. Because of economic crisis these regions will lose young people exceptionally. This group is mobile enough to look at the different opportunities presented by the labor market. The consequences are that some of these emigrants will go back to their place of birth and others will not move from their current surroundings.

In some cases young people, who are highly educated, will probably leave their region to find better vacancies. This process gives a negative impact on the intellectual capacity. It also makes these regions less competitive and unattractive (Pusch, 2013).

As mentioned before, housing vacancies is a direct consequence of population shrinkage. In order to tackle the rise of housing vacancies more policy attention was needed (Martinez-Fernandez et al., 2012). Several attempts have been made by different cities in order to revive the housing market. A common solution was to demolish neglected housing stock. Other solutions were to accommodate recreational locations and open spaces in a city to restore its vitality and attract new residents (Martinez-Fernandez et al., 2012).

In smaller cities, shrinkage is more visible than in larger cities, typical for this perception is the presence of vacant buildings. These abandoned buildings accurately reflects the impact of shrinkage because real estate loses its value, crime in these cities will increase and environmental problems arise. Ultimately, investment in these cities will decrease. The tax base of a city declines, as well as sports, shopping and cultural activities. A vicious circle is created in the environment of a city where it is more likely that people will leave.

The third sub question can now be answered: *What are the main consequences of population shrinkage according to existing literature?*

- Decreasing tax revenues
- Underused social and technical infrastructures
- Housing vacancies
- Abandonment of a region
- Environmental hazards
- Disinvestment and unemployment

The most important determinants of shrinkage have been given in this chapter. In

summary, the most important variables are education supply and employment. Other variables also have an effect on shrinkage. These variables will be included in my research. In the next chapter, these variables will be operationalised. Based on the theory (chapter2) the theoretical model of this study is:
PopulationDevelopment = B0 + B1*Educational Variables+B2*Employment variables + B3* Controlvariables + e

PopulationDevelopment = absolute growth or loss of population
Educational variables = all variables used in this study to capture education
Employment variables = all variables used in this study to capture employment
ControlVariables = all variables that are related to population growth

3. Data & Methodology

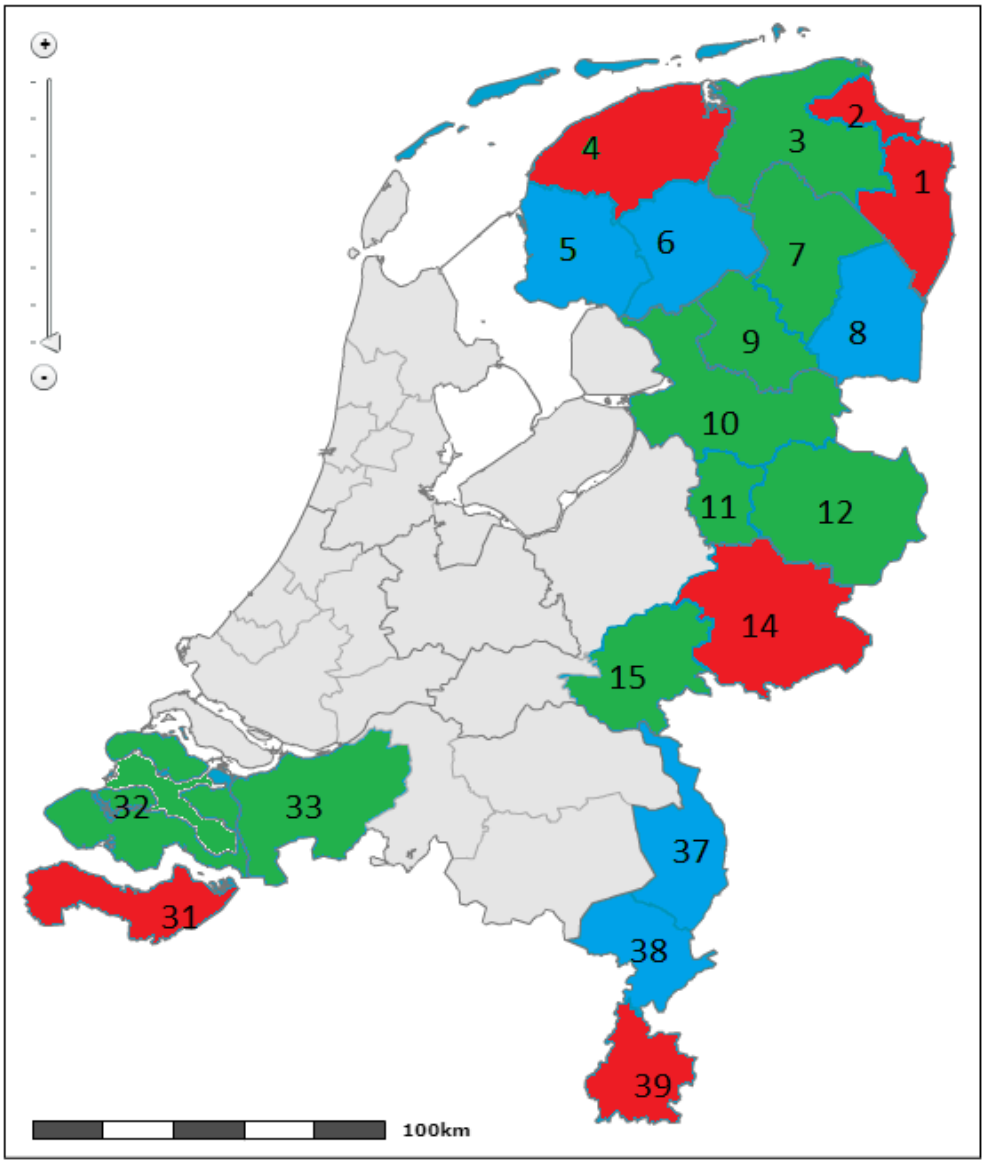
In the previous chapter, a theoretical framework of population shrinkage is given. As a consequence, a number of important determinants of shrinkage are explained. In this chapter, data about these determinants is used to assemble a database in order to explain and analyse shrinkage. All variables which may influence population shrinkage according to the theory (chapter 2), are included in this study. In the next section, results will be presented based on regression. This chapter is divided into data (3.1) and methodology (3.2).

3.1 Data

All data for this study is provided by Centraal Bureau voor de Statistiek (CBS). CBS is the main institute of statistical information in the Netherlands. The CBS provides both statistical information and predictions about future developments. As mentioned earlier, the definition used by the Dutch government for shrinkage is also used in this thesis, namely regions are shrinking if they experience an annual population decline of at least 3%.

In total, there are 17 years of unique data for 20 different COROP regions. The total number of observations is nT, i.e. 20*17 makes 340 unique observations. The COROP regions used in this study can be found in figure 3.1.

Figure 3.1: COROP regions used in this thesis



Data in this study is used for the years 2000-2016. There are several reasons for this timespan. First, population shrinkage occurred in these years in The Netherlands. In 1996, population shrinkage already started to appear in Zuid-Limburg (Gybels, 2016). Since then, population shrinkage started to occur in more regions. In 2006, there was a breakthrough for the attention of this phenomenon, population shrinkage became reality for many regions (Gybels, 2016). Second, data for most of these variables were only available since 2000,as the CBS started collecting the necessary data. In table 3.1, an

overview of these variables can be seen with the associated years. Third, it is important that this study contains enough data. If more observations are included in this study, the power of the tests in this study will increase. This eventually will lead to more valid results.

Fourth, the time period should be large enough to interpret lagged effects as well. Lag effects are included in this model because it is suspected that the effect of independent variables on the dependent variable will take place with a lag of 1 year or more. A distinction can be made between long-distance migration and short-distance migration. Long-distance migration is assumed to emerge mainly from work and study motives, while the short-distance migration has to deal with household transitions and residential motives (Feijten & Visser, 2005).

Moving away costs money and energy, so a decision to move is not just made. A decision process precedes the actual move. Only when someone finds a new homes, whose expected usefulness exceeds the cost and difficulty of moving, they will decide to move (Jong & Fawcett, 1981). This decision process contains life cycle of households, changes in labor market and housing requirements. Because these considerations has to be made in order to move away to another location, I assume that this decision process and the effects of relocating to another region on population take about one year. That is why one year lag is included in this model. In table 3.1, an overview of the variables can be found. A distinction is made between dependent, independent and control variables.

Table 3.1: Overview of Variables

Variable	**Definition**	**Years**
	Dependent variable	
PopulationDevelopment	Population change in one year	1995-2018
	Alternative dependent variable	
Population	Total Population	1995-2016

Population%	Population percentage change in one year	1995-2016
	Independent variables	
LeerlingenPO	Number of pupils in primary school	2000-2016
LeerlingenVO	Total number of pupils in secondary school	2003-2016
LeerlingenMBO	Total student number in MBO education	2005-2016
StudentenHBO	Total student number in HBO education	2000-2016
StudentenWO	Total student number in University	2000-2016
Employment	Total number of jobs	1995-2016
Economic Diversity	Herfindahl Index used to display economic diversity in a region	1995-2016
BusinessLocations	Total number of business locations	1995-2018
	Control variables	
GDP	Total GDP per capita in euro	1995-2016
Newhouses	Total number of new houses in one year	1995-2016
HousingValue	Average house value in euro	1997-2017
AgeGroup	Different age groups (0-20;20-45;45-65;65+)	1995-2017
Density	Total number of people per km^2	1995-2017
PublicAmenities	Total number of amenities (Doctor; Hospital; Daycare; Restaurant; Cinemas)	2006-2016

Note, for the variables 'LeerlingenVO' 'LeerlingenMBO' and 'Public Amenities' data is not available for all the years between 2000 and 2016. These variables are therefore not included in the final model used in chapter 4. In order to capture the effect of these variables, alternative models are used, which can be seen in the appendix.

3.1.1 Education

As can be seen from table 3.1, different variables are used to capture the supply of education in a region, namely 'LeerlingenPO',' LeerlingenVO', 'LeerlingenMBO', 'StudentenHBO' and 'StudentenWO'. These variables all capture a different phase or

aspect of education in the Netherlands, from primary school, to secondary school and higher education. The first and most important type used in this thesis is total number of pupils in primary school ('LeerlingenPO'). Note, the number of pupils has been chosen as main indicator to identify education supply. Another option to capture education was to include total number of schools in a region. Unfortunately, there was not enough data available to be included.

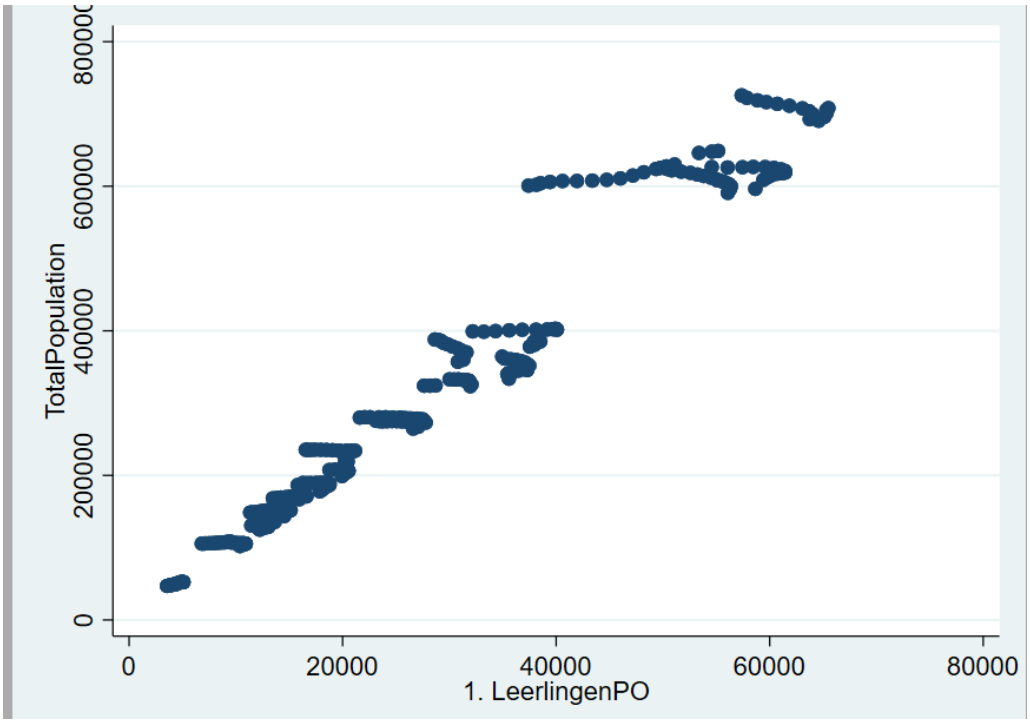
Pupils primary school (PO):

Numbers about primary school will be most important in order to identify supply of education in a region. The number of pupils in primary schools in a region is included in the database in three different ways, namely total number of students in a region; number of pupils per km^2 in a region; and number of pupils per 1000 habitants in a region.

As mentioned earlier, 'LeerlingenPO' is used as the main indicator for the effect of education on population. The reason for this is that data is best available. Data about other types of school are not always available or incomplete (i.e. 'LeerlingenVO' and 'LeerlingenMBO'). Primary school is a more pure way to measure number of pupils in shrinkage areas than secondary school, because secondary school is not offered in every municipality, or only partly. This could lead to wrong conclusions for the total sample size.

A scatter plot can be seen below, to show the relation between 'Total Population' and pupils in primary school. There are 20 different lines, representing the 20 different COROP regions. All regions have a different slope, which means that every region has its own development. Some are increasing, while other are decreasing.

Figure 3.1: Scatterplot between 'Total Population' and 'LeerlingenPO'



Pupils secondary school (VO):

Data is also assembled for secondary school. However, this variable is highly correlated with primary school. Therefore, this data is not included in most of the models in this thesis. An alternative model is used to only cover this variable.

MBO,HBO, WO:

The third form of education is higher education, or tertiary education. Higher education succeeds on secondary school and is divided into three different levels: MBO, HBO and university (WO). The same applies for 'LeerlingenMBO' as to 'LeerlingenVO'; this variable is highly correlated to primary school and is excluded in the main model. 'StudentenHBO'and 'StudentenWO' are merged in one variable, namely 'StudentenHBOWO'. The reason for this adjustment is that these variables apart from each other would be highly correlated and therefore cause multicollinearity. The presence of students in HBO education and Universities can be a way to present high educated people in a region. However, this variable does not show the level of education

to the entire population. Therefore, the variable StudentenHBOWO is only used to capture supply of education and not as a way to measure education level in a region.

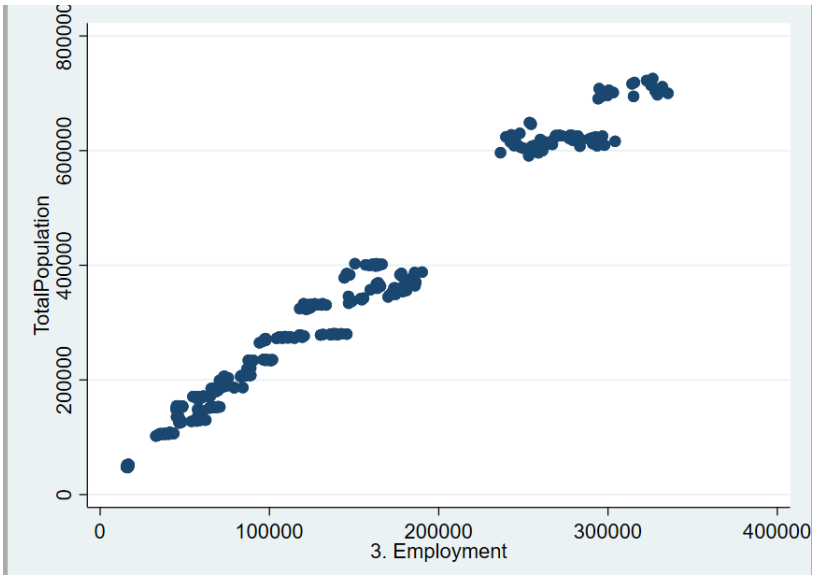
3.1.2 Employment

The other main variable of interest in this thesis is employment in a region. From table 3.1, the indicators used for employment in this thesis are: Number of jobs in a region; number of business locations in a region and a diversity index (the Herfindahl-Hirschman Index).

Employment & BusinessLocations:

The total number of jobs in a region obviously is a good indicator for employment in a region. More jobs in a region would logically lead to more people in a region. Next, the total number of business locations in a region is used as indicator for employment. In figure 3.2, the relationship between population and employment can be seen.

Figure 3.2: Scatterplot 'TotalPopulation' and 'Employment'



Economic Diversity

As mentioned above, not only the total number of jobs is used as indicator for

employment, also the variety of jobs is important for population development. Therefore, an economic diversity index is used. For this index, the calculation method of Herfindahl-Hirschman Index (HHI) is used. The Herfindahl Index is a mathematical formula for displaying dispersion in any topic. Jobs of a region can be highly concentrated or diversified. To measure diversity in a region, total number of jobs per business branch (sector) is measured.

The formula for calculating the diversity index is as follows: (%sectorA)^2 + (%sectorB)^2 + … + (%sector)^2

In this thesis, 11 different business sector are used in order to calculate the diversity index of a region, these are:

- **1**: A+B: Agriculture, Forestry, Fishery
- **2**: C-F: Industry and Energy
- **3:**G Trade, **4**: H Catering Industry **5**: I Transport and Storage **6**: J Financial Services **7**:K Rental and trade and real estate **8**:L Public Administration and Government Services **9**:M Education **10**:N Health care and welfare **11**:O Culture, Recreation and other services

A higher number of this index means more specialization in a region and less diversification. Specialization is in general considered to be bad for population growth. According to the literature, downfall of these specialized sectors can have dramatic consequences for a region. Losses in total number of jobs can be difficult to absorb and eventually lead to a crash in the viability of a region. Therefore, I expect that shrinkage regions will have a higher diversity index compared to anticipation regions and especially growth regions

In table 3.3 the average results of the diversity index can be found per region. A higher number of the diversity index means that a region is less diversified. In general, shrinkage regions tend to have a higher index number than anticipation regions and growth regions. Therefore, it is likely that economic diversity has a negative relation with population growth, this will be tested in chapter 4.

Table 3.3:Average diversity index per different type of region (2014)

Shrinkage regions	Anticipation regions	Growth regions
0.1291	0.1243	0.1163

Source: *CBS*

In addition, unilateral economy entails an economy that depends on one or a few industries where large groups find employment. In the event of disruption of this industry, large unemployment arises, which may be accompanied by the withdrawal of the population in connection with the search for work. So a multifaceted supply of sectors (low index number) in the economy reduces dependence on the disappearance of a sector. The disappearance of an industry can have to do with the appearance of low-wage countries to the market, making it much too expensive to continue to produce certain products in the region. Or that the energy requirement changes through various environmental requirements, for example from coal to oil. Examples are the mine closure in Limburg and the disappearance of the textile industry in the Twente area.

3.1.3 Additional controlling variables

A regression model with only education supply and employment variables to explain population shrinkage would be too simplistic. Other variables might influence population as well, or must be included in the model to control for. The other variables used in this study are: GDP, Newhouses, HousingValue, Age groups, Public Amenities.

GDP

Income can play an important role in the choice for people to settle in a region, as can be seen in chapter 2.4.c. To include the factor income in my model, the variable GDP is used. Gross Domestic Product is measured as GDP per capita.

Housing

Another important factor which can influence the choice for people to settle in a region

is housing. Every year new houses will be built and other are demolished. In my model the variables Newhouses and HousingValue are used as main indicators. Definitions for these variables are:

NewHouses: The number of new homes completed in a given year in a region.

HousingValue: The average house value in a region, only described by WOZ as dwellings serving as main residence with a value greater than zero euros.

Age Groups

In order to analyze differences between shrinkage regions and growth regions, it is also important to have a look at the composition of the population in a region. In my model, the population is divided into different age groups. As mentioned in chapter 2, a high presence of elderly (65+) has a strong relation with shrinkage. In my model the following age groups are used: 'Young' (0-20 years); 'Middle' (20-65) and 'Elderly' (65+).

Public Amenities

As mentioned earlier, public amenities play a major role for residents to establish themselves in a region. Therefore, data about public amenities is included in this study to research the effect of this variable on population shrinkage. The amenities used in this study are: general practitioners, hospitals, daycare, supermarkets, restaurants and cinemas. The average number of these public amenities in a region are used in this study. Because, data is only available since 2006, an alternative model must be estimated in order to capture the effect of public amenities on population shrinkage.

3.1.4 Excluded variables

As mentioned before, all variables in this study are based on the theory about population shrinkage. Some variables in the theory (chapter 2) are not included in the analysis of this study. These are:

LeerlingenMBO: Total student number in MBO education

Density: Number of inhabitants per km^2 in a region.

Surface: Surface of COROP region in km^2.

EducationLevel: Level of education of people in a region.
Data for the variables 'LeerlingenMBO' was only available since 2005. The model would miss six years of observations if these variables were included. This would lead to a significant decrease of the power of my results. Therefore these variables were not included in the final model.

The variables 'Density' and 'Surface' are not included for model-based reasons. Including the variable 'Density' would cause endogeneity to the model. Endogeneity broadly refers to situations in which an explanatory variable is correlated with the error term. In other words, both on the left and right side of the equation population will be present. 'Surface' will not change over time for regions and therefore cannot be used for panel data. Note that some variables included in the model are used per km^2. This way, the variable 'Surface' is used indirectly.

There is no data available for the variable Educationlevel. Only the number of students in HBO and WO education are available. Unfortunately, this does not capture the level of education of the entire population in a region.

A disadvantage of excluding these variables in the model is that population shrinkage cannot be fully analyzed. Some variables which might explain population shrinkage, are not researched. This causes omitted-variable bias to occur in this study. This happens when a statistical model incorrectly omit relevant variables. This leads to a model that attributes the effect of the missing variables to the estimated effects of the included variables. Therefore, the results of this study may be biased.

Now, all variables are mentioned and operationalized, a summary of the database of the final model can be found in table 3.4. In the appendix (table 6.3), a correlation table can be found.

Table 3.4: Summary of database

Variable	Observations	Mean	Standard deviation	Min	Max
PopulationDevelopment	340	647.5559	1375.641	-4563	5606
LeerlingenPO	340	27229.85	16925.29	3548	65501
StudentenHBOWO	340	10209.35	10471.3	795	41114
Employment	340	127200.3	88162.89	15500	335400
Diversityindex	340	0.1365.3	0.017810	0.0913103	0.175162
GDP	340	29268.97	8106.746	16203	75635
Newhouses	340	1021.271	779.09	43	4615
HousingValue	340	167200	47744.17	50000	249000
Young	340	.2347274	.0166461	.1811	.2723
Middle	340	.5972259	.0184408	.5546	.6397
Elderly	340	.1680512	.0247981	.1278	.2421

3.2 Methodology

Now that the data is mentioned and operationalised, I provide the empirical strategy for my thesis. I want to research the effect of different independent variables on population shrinkage in Dutch regions. However, in order to study population shrinkage, population development is used as dependent variable. An independent variable with a positive coefficient on population development implies a growth in population for that region. In reverse, a negative coefficient of an independent variables implies population shrinkage in a particular region. As mentioned in chapter 1, both natural growth and migration are included in order to study population development. If one of these variables were excluded, only one part of population change would be analysed and not population change as a whole.

Multiple regression analysis is performed in order to research population development in Dutch regions. For multiple regression to give valid results, data must meet certain assumption. These assumptions are:

- Your dependent variable should be measured at the continuous level.
- You have two or more independent variables, which should be measured at the continuous or categorical level.
- A linear relationship is required between the dependent variable and each of the independent variables.
- The data needs to show homoscedasticity
- No multicollinearity must occur in the data. This happens when two or more independent variable are highly correlated with each other
- There should be no significant outliers and the residuals should be approximately normally distributed

In this study, the assumptions have been tested. It can be concluded that the data failed the following assumptions:

- Heteroscedasticity (Breusch-Pagan LM test is run. Pr=0.0000)
(Modified Wald test is run, chi2(20)=16607.10 Prob>chi(20)=0.000)
- Autoregression (Wooldridge test for autocorrelation in panel data is run. The H0: no first-order autocorrelation is rejected (F=93.475 and Prob>F=0.000).
- Multicollinearity (see appendix, table 6.2)

When you work with real-world data, it is fairly typical that data fail one or more of these assumptions. The data included in this study consist of time series, so a level of auto regression of the data was to be expected. Some of the variables should also be expected to correlate with each other. In order to still run multiple regression in this study, corrections will be made for these failed assumptions.

These corrections are:

- PopulationDevelopment is used as dependent variable, and not total population or percentage change of population. Population development takes size of the region

account, unlike total population.

-: Population development is influenced by what happened a year earlier, not the same year. For that, lags are included in the specification model.

-: First difference variables are included in the model. The first difference is taken from all variables. As a result the mutual correlation and multicollinearity decreases. In addition, the dependent variable in the model is used as first difference variable. Therefore, all the independent variables are also included as first difference variables.

-: If both the variables 'LeerlingenPO' and 'LeerlingenVO' are included in the model, it would suffer from multicollinearity and have a high correlation with each other. Therefore, 'LeerlingenVO' is excluded in the model.

-: In order to cover employment in the model, three variables are included in the data: total number of jobs; business locations; economic diversity index. However, if both the first two variables are included in the model it would suffer multicollinearity. Hence, business locations is excluded in the model.

-: The economic diversity index is used to represent variety of employment in a region. Therefore the Herfindahl index method is used and calculated as follows: (%sectorA)^2 + (%sectorB)^2 + … + (%sectorN))^2

After these adjustments, the theoretical model (§ 3.1) ,the final model in this study is:
PopulationDevelopment = Bo + B1 * L1.d.LeerlingenPO+ B2* L1.d. StudentenHBOWO+B3* L1. d.Employment+ B4* L1.d.EconomicDiversity + B5* L1.d.GDP + B6* L1.d. Newhouses + B7* L1.d.HousingValue + B8 *L1.d.AgeGroups (Young, Middle, Elderly)+ e
From this model, the regression models have been run and interpreted.

4. Results

The previous section explains the data used and gives an overview of the methodology used for my estimations. In this section, the results are presented and interpreted in depth what these results say regarding the main research question. Afterwards, the results of these models will be interpreted and discussed. First, the results regarding the analyses in Stata is shown.

4.1 Data

As the data comprises time series for 20 regions a panel regression model is necessary for predictions. After doing a Hausman test a fixed effects panel regression was selected for the analysis. The Hausman test indicated that the fixed effects model would do a better job of predicting the effect on the dependent variable. The data was checked for the parametric assumptions and for issues stemming from using long data panel (longer than 15 years). After doing a test for heteroscedasticity, serial correlation and cross sectional correlation between panels, the fixed effects regression was expanded with a general least squares regression that corrected for autocorrelation and heteroscedasticity. Note, I assume all other factors outside this model ceteris paribus, which means other factors being equal or held constant.

4.2 Statistical models

Different estimation techniques are used to analyse the effect of determinants on shrinkage to find a model with adequate predictive value. The estimation techniques used in this study are Pooled OLS, Fixed effects (FE) and Generalised Least Squares (GLS). A consideration between these models is made which best reflects the results. The GLS model is chosen to reflect the results of this study. This model corrects for heteroscedasticity and autocorrelation, and cross sectional correlation. The results of the GLS model can be seen in Table 4.1. Afterwards, these results will be interpreted and

discussed. The outcomes of the Pooled OLS and FE can be seen in the appendix but will not be interpreted.

Table 4.1: Overview of results

Variables	Coefficient	Z-statistics
LD.LeerlingenPO	0.0562**	2.319
LD.StudentenHBOWO	0.0812*	1.746
LD.Employment	0.00369	0.720
LD.Interaction	-1.26e-07	-1.004
LD.DiversityIndex	-8,463***	-4.145
LD.GDP	0.0147	1.623
LD.Newhouses	0.117***	5.353
LD.HousingValue	0.000778	0.220
LD.Young	-70,573***	-4.454
LD.Elderly	-37,886***	-2.818
Dkrimp	-1,702***	-41.08
Danticipeer	-1,145***	-28.54
Constant	2,090***	13.97
Number of Observations	300	
Number of ID	20	

*** p <0.01, ** p<0.05, * p<0.1

As can be seen, for every variable a lag and first difference is used. Dummy's for shrinkage (Dkrimp) and anticipation (Danticipeer) regions are included, as well as year dummy's (i.Year).

The GLS model is chosen as estimation technique because this technique corrects for heteroskedasticity and autoregression. Therefore, results of this model are most valid. A dummy for shrinkage and anticipation regions are used in order test if there are significant differences between these categories. Year dummies' are included in order to capture the year effect of the regression. Furthermore, the multicollinearity and correlation between variables are tested for and can be seen in table 6.2 and 6.3 (see appendix). The multicollinearity in this model is low and no variable passes the 10.00 mark in the applied VIF test. In addition, the correlation table shows that none of the variables is highly correlated with one another (<0.8).

Now, each variable will be interpreted separately. In general, all the variables will be interpreted for their significance and the sign of the coefficient. A variable can be significant or not significant and either has a positive or negative impact on the dependent variable population development. If the variable is not significant, the variable cannot be interpreted and has no significant impact on population development. If a variable is significant, the sign of the coefficient will be looked at. If the sign is positive, the variable will have a positive impact on population development, resulting in population growth. If the sign of a variable is negative, the variable will have a negative impact on population development, resulting in population shrinkage. The meaning of these outcomes and the impact they have will be further discussed in section 4.4.

The most important variables in the model are '**LD.LeerlingenPO'** and '**LD.Employment'. LeerlingenPO** is significant at the 5% level and positive (0.0562). Thus, there is a significant relation between education supply and population shrinkage. Hence, it is estimated that population will shrink in Dutch regions if the number of

pupils in primary school decreases.

Next, the variable LD.**Employment** is not significant and can therefore not be interpreted. This outcome shows that employment does not have a direct effect on population shrinkage

The variable 'Economic Diversity' is significant at the 5% level and negative (-8.463). The third sub question can now be answered: *Does diversity of employment in a region have an effect on population shrinkage?*

Diversity of employment does have a significant effect on population shrinkage. The results show that lack of diversity in a region has a negative impact on population development. In other words, if employment in a region is specialized (a high diversity index), total population is estimated to decrease. Therefore, in general, it can be concluded that, diversification of employment in a region is vital for a region to prevent population shrinkage to occur. In reverse, a specialized economy in a region helps shrinkage to grow. The theory also suggests that shrinkage regions are less diversified than growth regions.

In order to calculate the interaction variable between education and employment, a new variable has to be generated. This is done by: gen EducationEmployment = LeerlingenPO*Employment. Introducing this variable into the regression creates a non-significant variable. Therefore this interaction effect cannot be interpreted and has no effect on population shrinkage.

Consequently, all the other variables can be interpreted as follows: LD.StudentenHBOWO is not significant at the 5% level and therefore cannot be interpreted. Thus, presence of high educated students on population development is negligible. Next, the variable 'LD.GDP' is not significant at the 5% level and therefore cannot be interpreted. This means that the overall level of the economy, in this case GDP,

has no significant effect on population development.

Next, the variable Newhouses is significant at the 5% level and positive (0.117). The variable 'HousingValue' is not significant and therefore cannot be interpreted. Thus, only the number of new houses in a region have a significant impact on population development, and not the value of these houses.

The age groups 'Young' and 'Elderly' are both significant at the 5% level and both negative (-70,573 and -37,886). These variables are compared to the variable 'Middle'. I suspect a different sign between 'Young' and 'Elderly', because they are opposite to each other. Therefore, this outcome is rather odd and implies that presence of young and elderly people have a negative impact on population development comparted to the age group middle (age 20-45).

Other variables used in the model are year dummies' from 2003-2016. Two years of the model are excluded due to using lag and difference variables. Another year is excluded from the model which is used as base year. A test has been run in Stata in order to test whether year dummies as a whole are significant (chi2(14)=2400.47, Prob=0.0000). From this test, it can be concluded that the year dummies' as a whole have a significant impact on 'Population Development'. A reason for why year dummies' as a whole are significant could be the impact of the economic crises during these years.

4.3 Alternative models

In this section the effect of LeerlingenVO and Public amenities, Birth surplus will be researched with alternative models. Reason for this is that a database with fewer years will be used, namely 2003-2016 for LeerlingenVO and 2006-2016 for public amenities.

LeerlingenVO

Overall power of the model will decrease, because less observations is used (N=240)(see appendix). In the GLS model, LeerlingenVO is not significant and therefore cannot be

interpreted. Fewer variables in the model are significant.

Public Amenities:

Overall, the power of the model will decrease, because less observations is used (N=160). We see the same outcome here as with the model with LeerlingenVO, fewer variables are significant. If we look at each Public Amenities variable separately, we see that all variables are not significant and therefore cannot be interpreted. From this it can be concluded that public amenities do not have an effect on population shrinkage.

4.4 Discussion

In this section the results of this study will be compared with existing literature. Moreover, the expected outcomes in this study will be explained.

Education

Interpretation of the variable LeerlingenPO shows that it has a significant effect on population development. This is in agreement with the theory in chapter 2. Feijten and Visser (2005) researched the reasons for people to migrate in Dutch regions. They found a significant impact for young people moving away to another region for study-related reasons. Especially in long-distance migration study-related reasons dominate. Therefore, this finding was to be expected.

Now, hypothesis 1 can be interpreted: H0: There is no relation between education supply and population shrinkage in Dutch regions.

According to the results in this study, hypothesis 1 is rejected at the 5% level and the alternative hypothesis is accepted. Supply of education does have a positive impact on population development. Hence, it is estimated that population will shrink in Dutch regions if the number of pupils in primary school decreases.

However, a significant relation between StudentenHBOWO and population development

cannot be found at the 5% level (only on the 10% level). A possible reason for this is that, the variable LeerlingenPO most likely captures the educational effect of the model. Both variables try to explain the same effect, namely the presence effect of education supply in a region.

Even though the level of education is not fully researched in this study it is interesting to see the effect of education level on population development. Unavailability of data is the most important reason for not including education level in this study. However, a study done by Lutz and KC (2011) show that level of education has a negative effect on population growth. Female education is associated with lower fertility at the individual level, this means that a population with a high proportion of educated women have lower overall birth rates. This leads to a reduction in the population growth rates. Therefore, universal secondary female education has been suggested as an effective way to lower population growth in a region.

Employment

If we look at the impact of employment in a region, the results of this study and the theory mentioned in chapter 2 are in conflict. Verwest and van Dam (2010) found a significant effect of population shrinkage on regional economy. Feijten and Visser (2005) also showed significant evidence for migration from people due to work. Finding a job is, besides education opportunities, the most important motive for people to leave their municipality and move away (Das & de Feijter, 2009). Therefore, the outcome of this study was not to be expected. Hypothesis 2, H0: There is no relation between employment and population shrinkage in Dutch regions, cannot be rejected. Possible reason for the lack of evidence in this study could be due to low number of observations in this study. Also, it could be that the effect of employment in a region is already captured by the diversity index. These shortcomings will be further outlined in the section limitations (5.2)

Next, the diversity of employment in a region is also researched in this study. The theory

suggests that shrinkage regions are less diversified than growth regions. Especially in the industrial sector, shrinkage region are overrepresented. The same applies to the health sector in Dutch regions, albeit in a lesser extent. This effect is also found in this study. A positive and negative relation between the diversity index and population development was found. Both the theory and outcome of this study are in agreement, therefore the outcome of this study was to be expected.

The fact that the interaction variable of employment and education is not significant is not in agreement with the theory. In this study, there is no significant effect between education supply and employment. Therefore, Hypothesis3 (There is no interaction effect between education supply and employment in Dutch regions) cannot be rejected. This outcome was not expected and it was assumed that these variables would strengthen each other. Reason for this deviation could be due to omitted variable bias. Several factors for explaining population development are not included in this study due to unavailability of data.

Other variables

The housing market, GDP and age groups in Dutch regions are used as control variables in this study. The relation between the variable 'Newhouses' and population development is significant. This is in agreement with the theory. The theory suggests that new houses are only built if there is enough demand for it. Thus, a positive coefficient of 'Newhouses implies a positive impact on population development. However, the variable 'HousingValue' is not significant. A possible explanation is that the effect of the housing market is already captured by 'Newhouses' and not by the value of dwellings.

Next, the variable GDP is also not significant. This is rather odd, in most papers, level of economy in a region matters for migration. Subsequent, the age groups Young and Elderly both have a significant effect on population development. According to the theory, presence of young people should have a positive impact on population growth

and presence of elderly a negative impact on population growth. In general, young people are extremely important for a region to stay vital. This is in agreement with the theory of dejuvenation. The outcome of this study could possibly that effect of young people is already captured by 'LeerlingenPO'. The fact that elderly people have a negative effect on population development could be that elderly are less mobile. Another reason, could be that cohorts are correlated with each other.

5. Conclusion

In this section, I first summarise the outcomes of this study and its implications. Thereafter, the limitations of the empirical analysis are discussed. Finally, recommendations and suggestions for further research are given.

5.1 Main conclusions

In this paper, the variables of shrinkage in Dutch regions are tested. Different models are used for the results. Multiple regression is used to analyses the relation between education supply and employment on population shrinkage controlled for the housing market, level of economy and different age groups in the society. After multiple regression analysis is run, the main question can be answered:

What is the effect of education supply and employment on population shrinkage in Dutch regions?

From the results, it can be concluded that the variable **'LeerlingenPO'** and **'DiversityIndex'** have a significant impact on population development. Both variables are significant on the 5% level. The variable 'Employment' however is not significant. LeerlingenPO has a positive effect on population development, while a specialized economy in a region has a negative impact on population development. Hence, it can be concluded that population shrinkage is stimulated by a specialized economy and reduced or contested by supply of education. Furthermore, total number of jobs in a region has no influence on population shrinkage.

Two other main findings are: no interaction effect between employment and education supply and a negative impact of the diversity index on population development. Based on the analysis of the regression models, only the first hypothesis can be rejected, while the others cannot be rejected.

5.2 Limitations

There are several issues in the empirical design in this study. First, the number of observations is rather low compared to other studies. This may cause power issues. It can be expected that the power of the statistical tests in this study is lower than the power in other papers. Fewer observations, means less accurate results. This makes it harder to interpret the results. The main reason for this is the low number of regions used in this study. Only 20 different regions are used in this study. For a next study a solution for the lack of regions could be to use data from municipalities instead of COROP regions. Then, the number of regions will be much higher.

Second, it is likely that the models used in this suffer from omitted variable bias. As mentioned in chapter 3, a simplified model is used in order to analyse population growth, other factors outside the model may influence population growth as well. This problem is visualized by looking at R^2 of the models. These are rather low(0.32). I tried to counter this by adding additional variables namely: Newhouses, Housing Value, Age groups. Possible variables that are missing are economic indicators and number of schools in a region. The economic indicators used in this study are the housing market and GDP of a region. Other economic indicators such as inflation, price index or Kuznets curve are not included in this study. The reason for not including number of schools in a region in this study is that that data was not available. However, in order to capture education effect number of pupils in a region is used in this study. The absence of a number of schools in the data has hereby been absorbed.

Furthermore, the data was obtained only from regions in the Netherlands. Therefore, the results may not be generalizable for Europe or the rest of the world. For example, it could be the case that the type of people and preferences of people differ from people in other countries.

Moreover, in this study only one-way regression is used. So, the effect of education supply, employment and other variables on shrinkage is researched. However, the effect

of shrinkage on these variables or the reciprocal effect is not examined. Instrumental variables are needed to account for this. Multiple regression also allows you to determine the overall fit of the model and the relative contribution of each of the independent variables to the total variance explained. Unfortunately, as mentioned earlier, the data used in this thesis does not meet all assumptions in order to run multiple regression, because the data suffers from heteroscedasticity and shows multicollinearity.

I assume causality between employment and education but there could also be reversed causality between these variables. Only one way causality will be examined in this thesis, so the effect of X on Y (X -> Y), thus only the effect of education supply and employment on shrinkage. Two-way causality would be a good topic for further research, which will also be mentioned in the last chapter. Note, I assume all other factors outside this model Ceteris Paribus, which means other things being equal or held constant.

Another limitation of this study is endogeneity between several variables. There is endogeneity between Population and GDP, as well as between population and 'LeerlingenPO' and Employment. Endogeneity broadly refers to situations in which an explanatory variable is correlated with the error term. In other words, both on the left and right side of the equation population will be present. Ignoring endogeneity leads to biased estimates.

5.3 Recommendations for further research

A first recommendation for further research is to create a database for other countries as well. Population shrinkage has many different causes and impacts. Shrinkage will have different impact on the environment. Especially in other countries, different circumstances will be present. If data is assembled for other countries, my research can be compared with several countries. In this case, we can see if there are universal indicators of population shrinkage and see if there are general outcomes of shrinkage.

Another recommendation for further research is to use two-way regression analysis. As mentioned earlier, in my thesis only the effect of certain variables on shrinkage are examined, but not the other way around. A two-way regression analysis makes it easier to interpret results. This research will lead to new insights and interesting outcomes.

Third recommendation is to include the effect of education level in a region on population development. Many studies have found a negative effect of education level and population growth due to decreasing birth rates. However, this study found no relation between total the number of students in HBO education or University on population growth. Hence, further research about the effect of education level on population development is useful in the field of population development.

6. Appendix

Table 6.1: Research area

#	*COROP-region*	*Municipalities*	*Categorie*
01	Oost Groningen	Bellingwede, Menterwolde, Oldambt, Pekela, Stadskanaal, Veendam, Valgtwedde	Shrinkage
02	Delfzijl en omgeving	Appingedam, Delfzijl, Loppersum	Shrinkage
03	Overig Groningen	Bedum, Ten Boer, Eemsmond, Groningen, Grootegast, Haren, Hoogezand-Sappemeer, Leek, De Marne, Marum, Slochteren, Winsum, Zuidhorn	Growth
04	Noord Friesland	Achtkarspelen, Ameland, Dantumadeel, Dongeradeel, Ferweradeel, Harlingen, Kollumerland en Nieuwkruisland, Leeuwarden, Schiermonnikoog, Terschelling, Tietsjerksteradeel, Vlieland, Waadhoeke	Shrinkage
05	Zuidwest Friesland	De Fries Meren, Sudwest-Fryslan	Anticipate
06	Zuid Oost Friesland	Heerenveen, Ooststellingwerf, Opsterland, Smallingerland, Weststellingwerf	Anticipate
07	Noord-Drenthe	Aa en Hunze, Assen, Midden-Drenthe, Noordenveld, Tynaarlo	Growth
08	Zuidoost Drenthe	Borger, Odoorn, Coevorden, Emmen	Anticipate
09	Zuidwest-Drenthe	Hoogeveen, Meppel, Westerveld, De Wolden	Growth
10	Noord-Overijssel	Dalfsen, Hardenberg, Kampen, Ommen, Staphorst, Stijnwijkerland, Zwartewaterland, Zwolle	Growth
11	Zuidwest-Overijssel	Deventer, Olst-Wijhe, Raalte	Growth
12	Twente	Almelo, Borne, Dinkelland, Enschede, Haaksbergen, Hellendoorn, Hengelo, Hof van Twente, Losser, Oldenzaal, Rijssen-Holten, Tubbergen, Twenterand,	Growth

		Wierden	
14	Achterhoek	Aalten, Berkelland, Bronckhorst, Brummen, Doetinchem, Lochem, Montferland, Oost Gelre, Oude IJsselstrek, Winterswijk, Zutphen	Shrinkage
15	Arnhem/Nijmegen	Arnhem, Berg en dal, Beuningen, Doesburg, Druten, Duiven, Heumen, Lingewaard, Nijmegen, Overbetuwe, Renkum, Rheden, Rijnwaarden, Rozendaal, Westervoort, Wijchen, Zevenaar	Growth
31	Zeeuws Vlaanderen	Hulst, Sluis, Terneuzen	Shrinkage
32	Overig Zeeland	Borsele, Goes, Kapelle, Middelburg, Noord-Beveland, Reimerswaal, Schouwen-Duiveland, Tholen, Veere, Vlissingen	Growth
33	West-Noord-Brabant	Bergen op Zoom, Breda, Drimmelen, Etten-Leur, Geertruidenberg, Halderberge, Moerdijk, Oosterhout, Roosendaal, Rucphen, Steenbergen, Woensdrecht, Zundert	Growth
37	Noord Limburg	Beesel, Bergen, Gennep, Horst aan de Maas, Mook en Middelaar, Peel en Maas, Venlo, Venray	Anticipate
38	Midden Limburg	Echt-Susteren, Leudal, Maasgouw, Nederweert, Roerdalen, Roermond, Weert	Anticipate
39	Zuid Limburg	Beek, Brunssum, Eijsden-Margraten, Gulpen-Wittem, Heerlen, Kerkrade, Landgraaf, Maastricht, Meerssen, Nuth, Onderbanken, Schinnen, Simpelveld, Sittard-Geleen, Stein, Vaals, Valkenburg aan de Geul, Voerendaal	Shrinkage

20 COROP regions, 167 municipalities

Table 6.2: Multicollinearity variables used in this study

Variable	VIF
Interation	7.64
Employment	6.36
Elderly	2.93
Young	2.58
LeerlingenPO	2.24
HousingValue	1.33
Danticipeer	1.32
Dkrimp	1.31
StudentenHBOWO	1.18
DiversityIndex	1.12
GDP	1.10
Newhouses	1.08
Mean VIF	2.52

Table 6.3: correlation between variables used in this study

	Ppp. Development	PO	HBOWO	Employment	Diversity Index	GDP	Newhouses	HousingValue	Young	Elderly
Pop. Development	1.00									
PO	0.23	1.00								
HBOWO	0.40	0.08	1.00							
Employment	0.18	0.27	0.13	1.00						
Diversity Index	-0.06	0.06	0.03	-0.16	1.00					
GDP	0.12	0.07	0.08	0.21	-0.07	1.00				
Newhouses	0.02	0.06	-0.03	0.12	0.21	0.08	1.00			
HousingValue	0.11	0.32	0.11	0.11	0.09	0.16	0.05	1.00		
Young	0.25	0.47	0.21	0.06	0.08	0.07	0.03	0.36	1.00	
Elderly	-0.29	-0.45	-0.27	-0.23	-0.02	-0.19	-0.09	-0.46	-0.75	1.00

Table 6.4: Fixed Effects and Pooled OLS model

Variables	**Fixed Effects**		**Pooled OLS**	
	Coefficient	z-statistics	Coefficient	z-statistics
LeerlingenPO	0.158	1.294	0.0228	0.0692
StudentenHBOWO	0.176	1.419	0.820**	2.623
Employment	-0.0129	-.403	-0.0491	-0.708
Interaction	2.09e-07	0.441	1.28e06	1.228
DiversityIndex	-11,619	-1.099	-13,492	-1.051
GDP	0.0312**	2.821	0.0262**	2.101
Newhouses	0.0817	1.402	0.126	1.114
HousingValue	0.0112	1.597	0.0228**	2.778
Young	-93,658	-1.399	-18,990	-0.279
Elderly	-103,226	-0.942	-219,309*	-1.890
Dkrimp			-1,287***	-3.950
Danticipeer			-655.8**	-2.626
Constant	689.6*	2.048	602.1	1.530
Observations	300		300	
R-squared	0.306		0.566	
Number of ID	20			

*** p <0.01, ** p<0.05, * p<0.1

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