Polycentric development in the Greater Oslo Region

An analysis of population development and commuting patterns between 2001 and 2015

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Abstract

This thesis explores the development of the urban structure in the Greater Oslo Region between 2001 and 2015, with the aim of discovering if the region has developed towards a polycentric structure. The development of population size is used as an indicator of morphological polycentricity, while the development of commuting patterns is used as an indicator of functional polycentricity. 6 regional cities, Sandvika, Asker, Lillestrøm, Jessheim, Ski and Ås, are analysed and compared to Oslo, the dominant centre of the region. The thesis finds that population has increased at a roughly similar annual growth rate in total for the regional cities as Oslo, and there is thus no indication of increased morphological polycentricity from 2001 to 2015. However, the share of the Greater Oslo Region population that commutes to the regional cities has in total increased slightly, and the share of the population that commutes to Oslo has decreased. At the same time the regional cities have slightly increased their reach as commuting destination, while Oslo's reach has decreased. The results indicate that the urban structure has become slightly more functionally polycentric from 2001 to 2015.
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# 1 Introduction

Urbanisation has never been as substantial as it is today. At the end of the last decade, more than half the world's population lived in cities and urban regions for the first time in history (UN 2014). 30 per cent of the world's population was living in cities and urban regions in 1950. In 2016, the share was 54.5 per cent (UN 2016). And UN population prospects estimate this number to grow to 66 per cent by 2050 (UN 2014); 2 out of 3 people will be living in cities and urban regions by 2050. The urbanisation projections show that all regions will face an increase in the share of the population living in cities and urban regions. The growth is not restricted to just a few regions, but less developed regions do have faster rates of urbanisation. Additionally, the size of cities is expected to continue growing. In 2016, 23 per cent of the world's population lived in a city with a population bigger than 1 million. By 2030 the number is estimated to be 27 per cent (UN 2016).

At the same time, calculations by the United Nations Human Settlements Programme (2011) estimate that between 40-70 per cent of greenhouse gas (GHG) emissions from humans come from cities when adding up emissions from entities within cities, and 60-70 per cent of emissions are estimated to come from cities when adding up emissions from the production of all goods consumed by residents of cities, even though cities only occupy 2 per cent of the world's territory. Cities and urban regions, therefore, play a key role in climate change mitigation. Indeed, it is in cities and urban regions that the greatest opportunities for mitigation measures with large effect exist (United Nations Human Settlements Programme 2011). Cities and urban regions should be considered crucial for creating sustainable solutions (Simon & Leck 2013).

To create sustainable cities all aspects of the city have to be sustainable. The transport system, the energy supply, the waste management, the built environment, the urban structure and so on all have to be sustainable. In the context of environmental sustainability and climate change, this translates to solutions that reduce emissions of GHG to a minimum to mitigate climate change.

In this thesis, I will focus on the development of the urban structure in the Greater Oslo Region. Specifically, I will be looking at the evolution of polycentricity in the region. In short, a polycentric urban region (PUR) is a region with several similarly sized centres, opposed to one dominating centre, also known as a monocentric region. There are several indicators of size in the context of polycentricity (Parr 2004). I will be looking at two
indicators. The first being population, an indicator of morphological polycentricity. The second being commuting patterns, an indicator of functional polycentricity.

A PUR is argued to cause a reduction in the total amount of distance travelled by people living in the region (Næss et al. 2011). This would of course be a step in the direction of a more sustainable region as most forms of transport are still associated with varying degrees of GHG emissions and negative local environmental effects. Reducing the total amount of distance people travel in an urban region would ultimately be beneficial from a sustainability point of view. This is an important reason that so many local, regional, national governments, and the EU aim to develop urban regions towards a polycentric urban structure, instead of a monocentric urban structure (Davoudi 2003). This thesis will research the state of polycentric development in the Greater Oslo Region (Stor-Osloregionen) and will ask whether the region has developed towards becoming polycentric to a greater degree between 2001-2015. In other words, this is a study into whether the smaller regional cities and centres in the region have become more important in terms of morphology and functionality relative to Oslo, the by far biggest and most dominant centre in the region.

1.1 Background

The background for this thesis is the strategic plan for Oslo and Akershus, principally the Regional Plan for Land Use and Transport in Oslo and Akershus (Regional plan for areal og transport i Oslo og Akershus), approved in December 2015 by Plansamarbeidet (2015). This plan is a strategic platform by the city of Oslo and Akershus county with a goal for the Oslo region to become a more sustainable and competitive region. The main objective for the plan is that the county governments of Oslo and Akershus, the municipal governments of Akershus, and the other relevant actors will harmonise their land use and transport planning through cooperation, and thus be able to reach the regional as well as the national goals. There are several challenges facing the region, e.g. a projected population growth of 350 000 people in 20 years, and this plan addresses these challenges by creating a common understanding of the challenges and forming a strategic plan to face them.

The plan also sets other goals for the region. Amongst others, that the urban growth pattern is concentrated and based on polycentric development and that the urban green space is retained, that the transport system connects the polycentric region together, to the rest of the country, and to other countries in a sensible way, and that the transport system is effective,
environmentally friendly, accessible to everyone, and has the lowest possible need for transport by car. There is also a common goal in this plan is to reduce the total amount of CO2 emissions in Oslo and Akershus by half by 2030. In addition, the national agreement on climate policy (Norwegian Ministry of Climate and Environment 2012) and Oslo Package 3\(^1\) states that all growth in personal transportation within the region must be from walking, cycling and public transport only; car use in the region must not rise. This goal is also part of the regional plan and will help achieve the other goals as well (Plansamarbeidet 2015).

The development plan for the region is outlined in the Regional Plan for Land Use and Transport in Oslo and Akershus (Plansamarbeidet 2015). The plan for the urban structure of the region is to continue with the current development towards a polycentric structure where regional centres gain importance. The plan establishes prioritised growth areas where 80-90% of the growth in people, employment, and land use must be located. The remaining 10-20% of growth should be limited to existing residential areas in the region. The prioritised growth areas are the regional cities in Akershus (Sandvika, Asker, Lillestrøm, Jessheim, Ski, and Ås), the city of Oslo, the city belt stretching from Oslo to Asker in the west, Ski in the south, and Lillestrøm/Kjeller in the east, and some prioritised local towns and settlements in Akershus. The city of Oslo must continue to develop as a capital city, and the regional cities must absorb a greater share of the overall growth and have a greater role in the region.

The urban development in the growth areas must be in line with the concept of compact city development and thus be functionally diverse and dense, and they must be connected through an efficient public transport system. The goal is to increase the employment density in these growth areas as well as the population density. This is so more people will live so close to work they can cycle or walk. At the same time, the public transport system must be developed with the goal of it being a natural choice for travel to the growth areas if the distance is too far for cycling or walking. This is for people who work but don't live in the growth areas, and for travel from the growth areas to other areas in the region (Plansamarbeidet 2015).

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\(^1\) Oslo Package 3 is a plan for the development of road and public transport infrastructure in Oslo and Akershus between 2008-2032 and includes financing for development of the infrastructure and operating subsidies for public transport.
The regional cities in Akershus are especially important for creating a polycentric urban structure in the region. They must absorb a considerable share of the overall growth in population and employment. The plan outlines a strategy for how these regional cities can be strengthened as regional employment centres by facilitating the location of businesses in the centre of the regional cities, or in areas with existing high employment density. At the same time, these cities should be developed with the aim of creating an urban environment, with a high standard living environment, and with an efficient public transport system. The regional cities are meant to be the main subcentres that will exist secondary only to Oslo in the hierarchy of the polycentric urban region (Plansamarbeidet 2015).
In addition to the plan by Oslo and Akershus, there are other plans for the region. One of these is the Coordinated Land Use and Transport Strategy for the Oslo Region, 2016 (Samordnet areal- og transportstrategi for OSLOREGIONEN 2016) by Osloregionen (2016). Osloregionen is an alliance consisting of 79 municipalities, including Oslo, and the 5 counties of Akershus, Buskerud, Hedmark, Oppland and Østfold, with a combined population of 2.3 million. The alliance describes itself as a "collaborative, political membership organisation" (Osloregionen 2018:1), with the goal of strengthening the Oslo region as a competitive and sustainable region in Europe. As a way of achieving this, the alliance formulated a coordinated strategy for land use and transport, published in 2008 (Osloregionen 2008), and an updated version published in 2016 due to new members in the alliance and new challenges facing the region (Osloregionen 2016).

This plan resembles the Regional Plan for Land Use and Transport in Akershus and Oslo by Plansamarbeidet (2015). The 2016 plan continues from the 2008 plan with one of the main land use strategies being a development based on polycentric principles. Growth should be concentrated in the existing cities so the cities can strengthen and become independent of Oslo. This polycentric strategy was chosen because it is believed that it will strengthen the international competitiveness of the region and be a crucial part of reducing GHG emissions from the region. The plan highlights polycentric development as a way of balancing the growth in the region and developing attractive cities outside Oslo as well. Because of the geographical size of the region, the plan differentiates between several spatial levels within the region where polycentric development is possible. What the plans calls "the centre of the Oslo region" is the most similar to the area encompassed by the plan from Plansamarbeidet (2015). This centre includes Oslo, the regional cities in Akershus, and in addition Moss and Drammen.

Going further back, in a white paper about development of Norwegian city regions to parliament from the Norwegian Ministry for Local Government and Modernisation in 2003, polycentric development for the Greater Oslo Region is highlighted as advantageous. The report draws on another report, "Østlandets framtid – Oslodominert eller polysentrisk. Scenarier 1996-2015" ("Eastern Norway's future – Dominated by Oslo or polycentric? Scenarios 1996-2015"), by the Eastern Norway Research Institute (1999), which argues that polycentric development would substantially reduce travel time between the areas that make up the region by improving transport connections between them.
The Norwegian National Transport Plan 2018-2029 (Nasjonal Transportplan 2018-2029) also formulates strategies for urban development that can best facilitate an efficient transport system. The plan agrees that a more concentrated city development policy is preferred for creating the best possible transport system. A recommendation is that development should be concentrated around public transport hubs to build upon the transport system. More people living close to public transport hubs makes the development of better transport offers possible, which helps towards achieving the main goal of zero growth in the share of people travelling by car. The national transport plan thus also supports the notion of polycentric development.

Outside Norway, polycentricity has also long been a policy goal. The European Spatial Development Perspective (ESDP), the policy framework for the future development of the territory of the EU and the European Commission, has polycentric development listed as the first spatial development guideline: "development of a polycentric and balanced urban system and strengthening of the partnership between urban and rural areas" (ESDP 1999:19). And similarly to the Norwegian plans, another guideline of the ESDP is to develop an integrated transport system that supports polycentric development. The aim is to develop city regions that are not only balanced but also sustainable, and help avoid excessive concentration of people and money in Europe. These guidelines have been taken to heart by many European countries that each have come up with concepts for polycentric development. For example, Denmark's "polycentric national centres", Ireland's "linked gateways", Belgium's "urban networks", Italy's "city networks", Germany's "metropolregionen", and Greece's "twin poles" (Meijers 2007).

1.2 Research questions

The goal of this thesis is to explore the development of the functional structure of the Greater Oslo Region over a 14-year period from 2001 to 2015 to see if the region has developed towards a polycentric structure during the period, in accordance with the goals of the regional and local governments in the region. This will show the past and current trend of polycentric development in the region and indicate what the future trend will be and whether planning policies with greater impact are needed to reach the goals of polycentric development. The following research question will be guiding the thesis and answered through a quantitative analysis:
Has the Greater Oslo Region developed towards a polycentric structure between 2001 and 2015?

This main research question thus explores the development of the overall structure of the Greater Oslo Region. To explore these changes in urban structure an examination of which regional cities have become more, or less, important will be done. One indicator for the morphological and one indicator for the functional aspect of polycentricity will be used to research this. The population development of the regional cities of Asker, Sandvika, Ås, Ski, Lillestrøm and Jessheim relative to the city of Oslo, and the development of commuting to the regional cities relative to the city of Oslo and employment centres in Oslo. The following sub-questions will help answer the main research question:

Has the population increased at a higher rate in the regional cities of Akershus in comparison to the city of Oslo between 2001-2015?

Has commuting to the regional cities of Akershus increased in comparison to commuting to the city of Oslo between 2001-2015?

1.3 Thesis structure

Chapter 2 will provide an overview of the theoretical literature most relevant to the research question. A short review of why polycentrism is relevant and how it's different from a monocentric structure. The definition of polycentricism used in this thesis will also be given, and the difference between morphological and functional polycentrism will be discussed. Then a review of why urban regions aim to develop towards a polycentric structure will follow.

In chapter 3, the study area will briefly be presented, the data will be presented, and its reliability and validity discussed. A discussion of how polycentrism is measured will be given in the section on validity. Then the methodology used to analyse the data will be reviewed and discussed.

Chapter 4 will provide a presentation of the results of the analysis. First, a more detailed presentation of the study area and the studied regional cities will be given for context, then the results of the analysis of population and the analysis of commuting will be given. Lastly, the results will be discussed.
Chapter 5 will conclude the thesis with an answer to the main and secondary research questions with reference to the results from the analyses presented in chapter 4.
2 Theoretical framework

The aim of this chapter is to give an outline of the most relevant theory on polycentric urban regions to understand what they are, how they can be measured, and why urban regions want to develop their regions towards a more polycentric structure. This will create a theoretical framework to analyse if the Greater Oslo Region has become more polycentric or not.

2.1 What is polycentric urban development?

In the simplest terms, a polycentric urban region (PUR) is considered the opposite of a monocentric urban region. The monocentric urban region was for a long time the primary model used to describe and analyse cities and urban regions. A monocentric urban region is a region with one clearly defined centre or dominating city. Traditionally this centre would be the Central Business District (CBD) or downtown, as hypothesised by Burgess (1925) in the concentric zone model. In this model, one of the first models of urban structure, the CBD is the employment centre that is surrounded by 4 distinct zones primarily of residential character. The supply of labour in this model thus travels inwards to the CBD from the surrounding suburbs.

Hoyt's (1939) sector model is similar in the regard that there is one clearly defined employment centre, with the difference being that there is an outward axial development from the CBD along transport routes, opposed to circular zones around the CBD. As cities continued to grow and transport technology evolved allowing people and economic activities to move outwards from the city core, the limitations of the monocentric model as a tool for describing the urban structures of contemporary city regions became clear (Klosterman & Musterd 2001, Bertaud 2003).

Harris & Ullman (1945) later developed their model of a city with several discrete centres of economic activity, the multiple nuclei model. In this model, the city is made up of several discrete centres. These centres can either have existed since the origins of the city or developed as a consequence of residential and industrial migration and specialisation. This model is considered an early reference to the concept of polycentricity (Davoudi 2003).

As a city grows in size observations has shown the monocentric structure tends to dissolve into a more polycentric structure, and the activities in the city spread out into clusters over wide areas (Bertaud 2003). This is only a trend, and so not the case for every city or
region, as Burger (2011) highlights. It depends on a range of factors, like the original structure of the region. Modern city regions can be predominantly monocentric or predominantly polycentric. However, most have a structure that lies in between. It is unlikely that a modern city region is completely monocentric or polycentric (Burger 2011).

In addition to the increased size of cities due to rise in populations and greater urbanisation, there are other factors that have influenced the urban growth patterns of cities. Davoudi (2003) points out a number of changes that had been observed by the 1970s indicating future cities would depart from the monocentric model. Economic activities were rapidly becoming more decentralised, new transport technologies facilitated increased mobility and in turn new mobility patterns and more complex commuting patterns, and changes in lifestyle and household structure also impacted mobility patterns. This led to not only people and households having increased flexibility and mobility, but also firms, which in turn also affected the spatial distribution of employment and thus urban growth pattern (De Goei et al 2010).

An especially important factor for the changing nature of urban growth patterns was the concept of business clusters that became popularised through the 1990s (Krugman 1991, Porter 1998). This focus on businesses in the same sector clustering together geographically to help increase productivity, innovation, and create new businesses led to a change in the spatial pattern of employment. More economic activities branched out from the CBD and were instead located in various clusters or subcentres in the same urban region (Davoudi 2003). This has led to the urban growth pattern qualitatively changing (Anas et al 1998). The monocentric model was unable to explain the emergence of these subcentres and the resulting changes in commuting patterns (Burger et al 2011.)

As a result of these changes, several new concepts and models to describe the city's structure were developed, the multiple nuclei model by Harris & Ullman (1945) being one of the earliest ones. Several of the concepts that were developed have strong similarities to the concept of polycentricity. Gottmann's (1957, 1961) concept of the megalopolis on the East coast of the United States describes the agglomeration of several metropolitan areas that make up a network of cities, from Boston furthest North, to New York, to Philadelphia and to Washington D.C. furthest south. Burton's (1963) concept of the "Dispersed City" describes a region made up of cities with a comparable size that are separated administratively and by open land but function as one unit in an economic sense. More recently developed concepts also have strong similarities to the PUR concept, like "city networks" (Camagni & Salone
1993), "multicore city-regions" (Westin & Östhol 1994), "network cities" (Batten 1995), and "polynucleated metropolitan regions" (Dieleman & Faludi 1998). There was a clear sign of a need for more up to date models and concepts that better reflect and describe modern urban structures.

A polycentric urban region can be defined, according to Hall & Pain (2006), as an urban region with a structure made up of several cities that can be geographically apart but have to be functionally connected to each other in a network. The region is dominated by a few cities that are more central in terms of importance in the network. These central cities are usually of somewhat similar size. A PUR will have several centres and it is difficult to highlight just one dominating centre in the region (Parr 2004). This is what mainly separates a PUR from a monocentric urban region with one clear centre.

However, this definition is a bit vague. The definition only gives a general idea of how to understand what a PUR is. It does not provide an exact way to say if a region is a PUR or not. Vasanen (2012) argues that a precise clear definition of what a PUR is yet to be developed. There are still several different analytical methods to find out if a region is polycentric, and there is still disagreement about exactly which characteristics have to be in place for a region to be considered polycentric (Vasanen 2012, Burger & Meijers 2012). Indeed, the concept of polycentricity has been subject to "conceptual stretching", meaning the number of properties ascribed to polycentricity and the number of situations polycentricity applies to has increased simultaneously, making it difficult to clearly define the concept (Meeteren et al. 2016).

In principle, polycentricity can mean the multi-nodal spatial clustering of any human activity due to the "complexity of applying an all-embracing notion of polycentricity to cities. Cities as rich, multifaceted and historically contextualised spatial phenomena encompass almost every aspect of social life" (Kloosterman & Musterd 2001:623). This causes a range of interpretations to be employed. But, typically, population or employment distribution is examined (Vasanen 2012).

In addition, further obscuring the concept, polycentrism can be interpreted both in a morphological and in the functional context, as Hall and Pain (2006) do. These two are considered different analytical concepts and there is considerable debate on whether polycentricity should just refer to the morphological aspect, or the functional aspect as well as the morphological (Burger & Meijers 2012). In a morphological context, a PUR is a region made up of several centres geographically located in the same urban system (Vasanen 2012).
The focus here is on the internal characteristics of the centres, like the population size and number of people who work there, and their spatial distribution (Burger et al. 2011). If a region has centres distributed in a more balanced way with regards to importance, i.e. centres located in the same region are close in size, a region is more polycentric (Burger & Meijers 2012). Much of the literature has interpreted polycentrism in this context, according to Green (2007).

In a functional context, a PUR consists of several centres located in the same urban system but which also have to be functionally connected. The centres have to exist in a network connected through flows between the centres and the other parts of the region. Humans are what mostly make up these flows and are usually used as the measure of how strong the connections are. This can, for example, be measured as commuting trips or other types of daily mobility like leisure and shopping trips (Vasanen 2012). Other types of flows are flows of goods, services, capital and assets, waste and pollution, water and other environmental resources, knowledge, and social norms. Each one of these flows create separate functional boundaries that do not necessarily overlap. Taken together these flows create the functional boundaries of the region, and because of the complexity of the interactions and multiple boundaries they create, the true functional boundaries of the region will be blurry (Davoudi 2008).

A region is considered more polycentric if the flows are distributed evenly between the centres and are multidirectional opposed to one-directional. In a functional context, the more important part is thus the spatial interaction in the urban region through the physical mobility of people, where denser flows of people to and from the centres indicate a stronger connection and more multidirectional flows indicate a stronger degree of polycentricity.

The similarity between these two approaches is the focus on balanced distributions. In both the morphological and functional approach, a region is considered completely polycentric if there is no dominant centre. The centres are relatively equal in terms of importance. In a morphological context this means equal size, and in a functional context this means there is not one dominant centre all the flows orient towards (Burger & Meijers 2012).
One of the leading and more detailed definitions of a PUR has been formulated by Parr (2004). This definition will help in creating a clearer understanding of exactly what a PUR is and what its distinctive spatial structure looks like. He suggests a set of requirements that have to exist for an urban region to be considered polycentric. Some of these requirements are in relation to another urban region acting as a reference point. Ideally, this reference region is in the same country and has roughly the same population and level of urbanisation. Parr (2004) argues the use of a national benchmark region is needed due to the diversity among nations when it comes to physical extent, population density, economic structure, and urban system, so what can clearly be considered a PUR in one country might not be considered a PUR in a different country.

The first requirement suggested by Parr (2004) is that there has to be a set of urban centres close enough to have a geographically clustered distribution instead of a random or regular distribution. The second requirement is that there exists an upper limit on the level of separation between the urban centres. This is so the PUR does not extend indefinitely so the concept loses precision. Often used is a travel time of one hour between neighbouring centres (Bailey & Turok 2001, Davoudi 2003).

Third, in addition to the upper limit, there is a requirement for a lower limit of separation between the centres. This limit is not easily specified but has to be in place so it is
possible to differentiate between a PUR and a conurbation where several urban centres have expanded and formed a continuous urban region (Parr 2004).

The fourth requirement is that centres of a given size in the PUR are located more closely than in the benchmark region. Fifth, the larger centres that make up the PUR do not have much difference in size. A centre cannot have a population size that dominates the other centres (Parr 2004).

The sixth requirement is that the interaction between the centres in the PUR is greater than between the centres in the benchmark region. This interaction can take various forms, like overlapping labour markets, commuting between the centres and to the centres from smaller places in the region, and trade. The interaction should have the consequence of interdependence so that the economies of the different centres vary with each other (Parr 2004). The seventh and last requirement is that the centres in the PUR have economic structures that are more specialised compared to the centres in the benchmark region. The specialisation can be similar or different between the centres. It is important to highlight that Parr (2004) argues that all these requirements are justifiable but imposing every condition might lead to a limited number of PURs worldwide because of overspecification.

Davoudi (2003) in her discussion of how to define a PUR also grapples with which distance between the centres in the region is small enough for them to be considered part of the same PUR. What is called a reasonable commuting distance must be defined. According to Davoudi (2003), most scholars writing about polycentricity see a maximum of one hour distance between centres as a reasonable time for defining a PUR, as Parr (2004) does as well. Using time, however, presents the potential of a PUR's boundaries continuously being expanded over time as transport speed increases with the introduction of new technologies and better infrastructure leading to greater distances being covered within the same 1 hour time frame. This necessitates an upward change in the spatial scale a PUR is viewed depending on the concentration of PURs in the region. With expanding boundaries one PUR might need to be combined with another PUR, potentially in another country, to form a new PUR. For example, if travel time between the centres making up the PURs of the Randstad in the Netherlands, the Flemish Diamond in Belgium, and the Rhine-Ruhr area in Germany is reduced to one hour then it might be best to consider them one PUR (Davoudi 2003), which might be so massive it resembles a megalopolis (Gottmann 1957).

Another factor to consider when defining a PUR, as Parr (2004) also discusses, is the amount of interaction between the centres. It is not enough that the centres are close enough
to allow regular interaction, the interaction must also actually exist, and be above a certain threshold for a region to be a functional PUR instead of a morphological PUR. Here the issues of how to measure this interaction, and the amount of interaction to use as threshold presents challenges in defining a PUR. Commuting patterns are the most common form of interaction measured. Non-work travel and flows of information and resources have also been suggested as good measures (Davoudi 2003).

An important distinction is also to be made between a PUR and a dispersed city, however similar the concepts may be. Whereas a dispersed city is generally defined as unorganised urban sprawl, polycentricity would be an organised system of subcentres. To differentiate between these two several factors have to be considered: whether or not the subcentres are employment centres only or activity centres, how large these subcentres are in terms of employment scale and density, and what is considered more important between the level of interaction between the centre(s) and sub-centres, or employment scale and density (Davoudi 2003).

Anas et al (1998) distinguish between two types of subcentres. The first type is older towns that have developed and become part of the expanded urban area, the second type is newly developed subcentres normally around hubs in a transportation network. These subcentres can be so far from the main centre of the region that they can be considered "edge cities". Edge cities are part of the third wave of the evolution of urban spatial structure. These edge cities are concentrations of office and retail space and often other types of development on the periphery of urban areas where virtually nothing existed before (Garreau 1991). The development of edge cities is mostly an American phenomenon but Anas et al. (1998) argue that there has been an emergence of edge cities in Europe as well along with suburbanisation. With the development of edge cities in an urban area, it is likely that a functional polycentric pattern will arise with it.

As a polycentric urban pattern emerges with the development of subcentres alongside the main city centre or CBD, cities with at least a few hundred thousand inhabitants will qualify as being polycentric to an extent (Meijers 2007). They are likely to have more than one employment centre within the city or the continuous built-up area. This is polycentricity on an intra-urban scale; the internal structure of the city. The concept of a polycentric urban region refers to polycentricity at a regional inter-urban scale. The region is here made up of several separated cities that used to be less connected and have now become more connected functionally (Meijers 2007).
This distinction between the intra-urban and inter-urban scale means that where you find a clear polycentric pattern at one scale, you might not find a polycentric pattern at a different scale, and instead find a monocentric pattern. The concept of polycentricity is thus dependent on scale. The intra-urban scale has traditionally been the most researched, especially in the United States, while the inter-urban scale and the concept of the PUR is a more recent research agenda (Vasanen 2012). At the same time, an inter-regional scale also exists. This scale is polycentricity with cities or metropolitan areas in several regions also can be in different countries. This can, for example, be at the level of Europe as a whole, like the "Blue Banana" in Europe or the megalopolis on the US east coast (Davoudi 2003).

There are several examples of regions that would classify as being a predominantly polycentric urban region instead of monocentric. The already mentioned Randstad region (Batten 1995), the Rhine-Ruhr region (Knapp 1998), and the Flemish diamond (Albrechts 1998, 2001) in North West Europe are typical examples of a PUR at a large inter-urban scale. Other large-scale examples are the San Francisco Bay Area (Cervero & Wu 1997), the Kansai area in Japan (Batten 1995), the Veneto region in Northern-Italy (Meijers 2007), and the Pearl River Delta in China (Yeh 2001, Meijers 2007). On a higher spatial scale, regions like the already mentioned Megalopolis on the US East Coast (Gottman 1957, 1961), and the Delta region in North West Europe made up of the Randstad, Rhine-Ruhr, and Flemish Diamond PURs (Priemus & Hall 2004)) have been identified as polycentric.

2.2 Why develop polycentric urban regions?

It is clear polycentricity is an urban structure many planning authorities in Norway and around the world actively are trying to develop urban regions towards. It has been a spatial development strategy in Europe since the early 2000s (ESDP 1999, Davoudi 2003), and is an important part of the spatial strategy for the Greater Oslo Region. In this section, exactly why polycentricity is such a prominent strategy will be discussed.

In the Regional Plan for Land Use and Transport in Oslo and Akershus, it is argued developing the urban structure in line with polycentric principles has several effects that will help achieve the overall goals of a competitive and sustainable region.

First, concentrating development to the prioritised growth areas/regional cities will lead to these cities seeing a growth in population, population density, and employment density, which in turn leads to the city being able to offer a more diverse and higher quality
set of services, cultural attractions, shopping areas, local amenities, and better public transport. All things that affect urban quality of life and require a population of a certain size; a "critical mass" of people. The alternative would be growth that's more spread out and leads to a greater amount of smaller cities instead of fewer bigger cities. Mouratidis (2017) shows that in the Greater Oslo Region, people who live in compact neighbourhoods have significantly higher satisfaction than people who live in sprawled neighbourhoods. Components of the compact city, like easy access to the city centre and what it offers, access to public transport, and land use mix, have a positive association with neighbourhood satisfaction.

The argument that polycentricity is the preferred urban development strategy because it leads to more compact cities of greater size also ties in with the agglomeration argument for polycentricity. This is the second reason. According to Meijers (2007), it is argued that a PUR would have potential for better economic performance due to taking advantage of economies of scale, complexity, and scope similar to monocentric regions but without the same costs incurred from the congestion, environmental pollution, lack of space and high land prices a monocentric structure often struggles with. This is also a reason the regional plan for Oslo and Akershus highlights (Plansamarbeidet 2015). It is argued that prioritising growth in the regional cities and strengthening them will also strengthen the preconditions necessary for business development with high employment density in the cities. These cities will have the conditions to develop business clusters or strengthen already existing business clusters, which will benefit the region as a whole. Indeed, Meijers et al. (2018) shows this is the case for PURs in Europe. PURs with higher degrees of functional integration also perform better.

Third, a reason often argued for developing a PUR is it will be more competitive internationally compared to if it was a fragmented region. It will have more of a chance at developing sources of competitive advantage, and the region can be marketed internationally more effectively due to its bigger size. This assumption is basically that a set of cities together will be stronger and have more to offer, and this will, in turn, lead to more regional growth than if they exist independently and risk being overlooked internationally. In a well-functioning PUR with a network of interconnected cities, the whole will be greater than the sum of its parts because of synergy (Meijers 2007).

Fourth, important from an environmental point of view, is that a polycentric structure, is argued, will lead to a more efficient and better public transport system. With more concentrated development around a few existing regional cities and their public transport hub,
the public transport in those cities would be able to offer a better service because of a bigger population with easier access to public transport. This would undoubtedly help in achieving the goal of zero growth in car traffic (Plansamarbeidet 2015). Engebretsen & Christiansen (2011) show that travel to city centres with a high population density has a larger share of public transport use and a lower share of car use, while travel to places outside city centres have a considerably larger share of car use and lower public transport use. One case study about this is Julsrud and Christiansen's (2014) study on Gjensidige. They show that when Gjensidige moved their office to a central location in Oslo, car use went down, public transport use went up, and at the same time, travel time and satisfaction with travel to work were almost stable. However, Engebretsen & Christiansen (2011) also show that density alone is not enough for higher public transport use. In cities smaller than 10 000 inhabitants, density has a marginal effect on public transport use. Other factors such as where services and shops are located and incentives for public transport might also play a role. Studies have also shown the opposite of this hypothesis. For example, in The Netherlands, development of a polycentric structure was found to be associated with the importance of public transport, cycling, and walking declining (Schwanen et al. 2001)

Fifth, also important from an environmental point of view, polycentricity is argued will lead to an overall reduction in travel distance per capita (Plansamarbeidet 2015). The reason for this is that with stronger subcentres in the region more people will live closer to an urban centre where they can work, have access to cultural events, consumption opportunities, and an urban "feel". If the subcentre grows big enough and is dense enough, the attractions in the subcentre might act as a replacement for the main centre in the region with the result that the number of longer trips to the main centre reduces, and the number of shorter trips to the subcentres increases (Røe & Saglie 2011). People who find work in a subcentre are also hypothesised to relocate closer to their new workplace to avoid time penalties from long commutes. A polycentric structure thus has the potential for reducing commuting distances through better co-location of work and housing. This is known as the co-location hypothesis (Gordon et al. 1989a, 1989b, 1991). Several empirical studies have shown that a decrease in total commuting distance and/or time is associated with polycentric development, for example in US metropolitan regions (Gordon & Wong 1985), Giuliano & Small 1991, 1993, Gordon et
al 1989a, 1989b, 1991, and Levinson & Kumar 1994), in Italian PURs (Veneri 2010), in German PURs (Guth et al. 2009), in Istanbul (Alpkokin et al. 2008), and in Beijing (Zhao et al. 2011). In addition, when people have shorter distances to travel they also tend to travel on foot or by bike in greater frequency (Engebretsen & Strand 2010), so total distance travelled by car has the potential to reduce substantially in a polycentric region.

The counterargument to this hypothesis is that if a regional city grows and more workplaces are located there, it might attract workers from all over the region and not only from areas in close proximity, causing a spatial mismatch between housing and employment (Cervero 1989). This would potentially cause total travel distance per capita in the region to increase because people are commuting longer distances to get to their work in a regional city that might be further away than the main city centre. This is especially likely if a regional city becomes a hub for a specialised industry where people are willing to commute longer. Indeed, several empirical studies have shown that a polycentric structure is associated with an increase in total commuting distance for various regions. For example in the San Francisco Bay Area (Cervero & Wu 1998), in Oslo (Næss & Sandberg 1996), in Dutch PURs (Schwanen et al 2003, 2004), in Paris, Lyon and Marseille (Aguilera 2005), and in Sydney (Black & Suthanaya 2002, Parolin 2005). Many explanations for why commuting distances went up instead of down in some polycentric regions have been suggested: constraints on the opportunity and desire to relocate closer to work due to the costs of moving and other factors (Crane & Chatman 2003, Schwanen et al. 2004), housing development not keeping pace with demand near employment subcentres (Cervero & Wu 1997), greenbelts around centres hindering needed housing development (Bae & Jun 2003), or because commuting may be seen as a positive use of time rather than a negative for some people (Mokhtarian and Salomon 2001).

It is important to note that in many of these mentioned studies on the effects of polycentricity most of the change in commuting distances is not explained by the urban structure. Schwanen et al (2004) criticise that many explanatory factors other than monocentric or polycentric structure are neglected. At the same time, studies have shown that different types of PURs can lead to different results (Schwanen et al. 2004). If a polycentric structure leads to a decrease in total commuting distance or not is a very complicated question.

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2 The results from Levinson & Kumar’s (1994) study on commuting in Washington D.C. show an increase in total commuting distance in the metropolitan region but also show a decrease in commuting time, which they attribute to better co-location of jobs and housing.
to answer, which has led to a polarised debate in the literature. All the conflicting evidence seems to indicate that many other factors play an important role for commuting distances and therefore the evolution of total commuting distance varies between PURs.

Sixth, a polycentric structure will also lead to better balance in the transport system according to Plansamarbeidet (2015). Today, they argue, commuters in the Greater Oslo Region commute towards the bigger employment clusters in Oslo and Bærum municipality, leading to overcrowding in one direction, and a lot of free capacity elsewhere in the public transport system. A polycentric structure would lead to a more even distribution of workplaces in the region and thus more balanced commuting patterns with more of the capacity in the public transport system utilised as there will be more counterflow commuting out of Oslo to the regional cities. Subsequently, there will be better public transport for counterflow commuting as well and this will make it easier to travel for other reasons than work by public transport in the region. There is however also the possibility that those commuting counterflow will commute by car instead of public transport (Cervero & Wu 1997, Schwanen et al. 2001).

The seventh and last reason for polycentric development is that it will lead to more efficient and sustainable land use (Plansamarbeidet 2015). With only a few existing cities and settlements in a region prioritised as areas for growth, existing green spaces and agricultural land in the region will be retained opposed to being built upon if growth wasn't limited. It is clear that there are a lot of benefits to developing polycentric regions. However, it is also clear that many of these beneficial consequences are not inevitable for every PUR and some of the argued benefits also have considerable uncertainty surrounding their legitimacy.
3 Data & Methodology

In this chapter, the study area, the data, and methodology used will be presented and discussed. Reliability, the quality of the data and its strengths and weaknesses, as well as validity, how well the operationalisation of the data measures the development of morphological and functional polycentricity, will also be discussed.

To find out if the Greater Oslo Region has become more polycentric or not, I will look at population development and commuting patterns in the region over time. The method used will be a quantitative temporal analysis of the population and commuting data. Geographic information systems (GIS) will be used to prepare and help operationalise the data, manage the data, and to present some of the results, SPSS will also be used to manage and prepare the data for analysis, while the analysis of the data will be largely done in spreadsheets using Microsoft Excel. Excel will also be used to present the results.

As there is no established method for measuring the development of polycentricity, and no study on polycentricity in the Greater Oslo Region has been undertaken before, the operationalisation and methodology is largely self-guided and based on the available data.

3.1 Study area

The study area for this thesis is the Greater Oslo Region (Figure 3.1), an urban region including and surrounding the capital and biggest city of Norway, Oslo. The region was defined by the Norwegian Ministry for Local Government and Modernisation in a white paper to parliament in 2003 (Norwegian Ministry for Local Government and Modernisation 2003). It is made up of 46 municipalities chosen based on how integrated they are in the region. An inner ring of neighbouring municipalities around Oslo municipality have the highest amount of commuting to Oslo, while an outer ring of municipalities, which have less commuting to Oslo but are still strongly integrated in the region (Norwegian Ministry for Local Government and Modernisation 2003). The region consists of several distinct built-up, or continuous urban areas (tettsteder3), with Oslo being the by far largest with a population of 958 378 in the

3 Definition of tettsted: https://www.ssb.no/a/metadata/conceptvariable/vardok/141/nb - accessed 04.04.2018
The continuous urban area in 2015\(^4\), and a population of 647,676 in the municipality\(^5\). The city of Oslo is the same as Oslo municipality, and the two will be used interchangeably in this thesis. A distinction will be made when referring to the continuous urban area of Oslo. The Greater

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\(^4\) [https://www.ssb.no/statbank/table/04859/tableViewLayout1/?rxid=b2d22993-a6e3-4800-bcdd-5f2e2e7a1100](https://www.ssb.no/statbank/table/04859/tableViewLayout1/?rxid=b2d22993-a6e3-4800-bcdd-5f2e2e7a1100) – accessed 04.04.2018

\(^5\) [https://www.ssb.no/statbank/table/05231/tableViewLayout1/?rxid=0b6a178c-97bb-44e3-8ea3-4cc35f4adef2](https://www.ssb.no/statbank/table/05231/tableViewLayout1/?rxid=0b6a178c-97bb-44e3-8ea3-4cc35f4adef2) – accessed 04.04.2018
Oslo Region also consists of two other urban regions, Drammensregionen and Mossregionen, which both have a high level of commuting to Oslo and are therefore considered part of the region.

The Greater Oslo Region has several centres in addition to Oslo. Centres are, in the white paper, defined as concentrations of population and employment, and examples are Sandvika, Lillestrøm and Ski, as well as Moss and Drammen. Combined, these centres and urban regions create an urban structure that is leaning more towards being polycentric than monocentric in a morphological sense (Norwegian Ministry for Local Government and Modernisation 2003). The Greater Oslo Region is today dominated by service and knowledge industries after going through a period of deindustrialisation like many other European cities and regions (Næss, Næss & Strand 2011).

The Greater Oslo Region is a particularly interesting case for studying the development of polycentricity in a functional sense. The region has had a strong population growth during the study period with the region being one of the top five fastest growing urban areas in Europe (Wessel & Barstad 2016), combined with a master plan that aims to develop a polycentric urban region. The development of the urban morphological structure in the region has been said to show signs of becoming more polycentric since the 1970s (Myhre 2008), and the development in the region since the 1990s can be characterised as "concentrated and compact" (Næss, Næss & Strand 2011: 117). At the same, there has been a high degree of consensus by politicians and professionals on this overall strategy (Næss, Næss & Strand 2011). With this in mind, it can be said the Oslo region has had good conditions for developing towards a more polycentric structure in the functional and morphological sense.

3.2 Data

3.2.1 Description of data

The main dataset used in this study is a secondary dataset with employment data for all of Norway collected, compiled, and distributed by Statistics Norway (Statistics Norway 2018a). The dataset has information about employment and place of residence for anyone between ages 15 to 74, registered living in Norway and expected to live in Norway for at least 6 months and have worked at least 1 hour in the week used as reference. The data is aggregated to the geographical level of the basic statistical unit (grunnkrets), the lowest level of
A basic statistical unit (grunnkrets) is the lowest geographical unit used by Statistics Norway to provide regional statistics for Norway. The purpose of the basic statistical unit (BSU) is to have small and consistent units which give a flexible basis for regional statistics. One BSU is comprised of one geographically contiguous area that is as homogenous as possible when it comes to nature, communication conditions and building structures. The BSUs are a subdivision of municipalities and each generally consists of a few hundred people, however, some BSUs in the bigger cities might have more (Statistics Norway 2018b). BSUs are well suited for studying trends over time as they remain relatively stable over time. The BSUs from 2001 are still very similar to those in 2015.

The commuting dataset was received in the format of a statistics file (.sav format), suitable for use in SPSS. The statistics are sourced from several sources of employment statistics. The main source is the registry for employers and employees (Aa-registeret) compiled by the Norwegian Labour and Welfare Administration (NAV), which employers have a duty to report their employees to. Other sources used are the Registry of Pay and Tax Deducted (LTO-registeret), and the Tax Return Registry (selvangivelsesregisteret) compiled by The Norwegian Tax Administration, and registries of military and civilian conscripts. The Aa-registry and the LTO-registry were replaced by a more modern electronic solution, called A-ordningen, from 2015. There should not be any continuation errors between the data from before and after 2015 because of this change (Statics Norway 2018).

The specific dataset used in this thesis has been further compiled by The Norwegian Institute of Transport Economics (Transportøkonomisk institutt – TØI). The dataset includes employment statistics for the years 2001, 2007, 2008, 2010, 2011, 2012, 2013, 2014 and 2015. This time frame coincides with a period of rapid growth in the Greater Oslo Region. It would be more preferable to have data for every year in this 14 year period to better examine the nuances in the data. For example, a rise in the share of commuters to one of the regional
cities between 2001 and 2007 may mistakenly be interpreted as a steady rise when in reality it decreased from 2001 to 2005 then rose rapidly to 2007 after the development of new workplaces in 2005. A rise from 2001 to 2004 and a decrease to 2007 might show up as no change at all. The period from 2008 to 2015 where every year is accounted for does not have the same issue.

The dataset also includes a differentiation between full-time employees (over 30 hours per week), and part-time employees (1-19 and 20-29 hours per week), and a variable that includes all hours combined. Only the variable with all hours combined is used in the analysis because the definition of commuting used in this thesis is any regular trip from the place of home to the place of work. Any amount of worked hours per week is therefore interesting as they all include regular work trips. Using all hours worked will also give a more complete picture of commuting patterns and thus the development of functional polycentricity in the region. An analysis that includes a differentiation between full-time and part-time employees would also be too comprehensive for the scale of this thesis. Other variables included in the dataset are distance between the home BSU and the work BSU, measured in number of kilometres on public roads, and measured in number of minutes by car on public roads in accordance with current road speed limits.

A dataset of population at the BSU level for 2001-2015 is used as the main source of data for the population analysis. In addition to these, there are several supplementary datasets used in this thesis. These are all secondary data, and are mainly geographic datasets used to prepare, analyse and present the results. These datasets have been collected, compiled and distributed by the Norwegian Mapping Authority (Kartverket) and Statistics Norway. The geographic datasets include a dataset containing the BSUs in Norway in 2015. 2015 is used to avoid the changes that were made to BSUs after which would make the dataset incompatible with the other data connected to BSUs. This dataset was provided by The Norwegian Mapping Authority on request. This, and the other geographic datasets, are in the shapefile format, a common spatial data format used in geographic information systems. The N2000 dataset from the Norwegian Mapping Authority is used to show municipal boundaries, and the Oslofjord. This dataset is in the scale of 1:1 500 00 to 1: 3 000 000, which suits the maps made for this thesis well. Another geographic dataset used is a dataset containing the continuous urban areas (tettsteder) in the region from Statistics Norway, as well as a geographic ESRI network dataset of roads in Norway from the Norwegian Public Roads Administration. The network dataset is used to analyse driving times in the region. This
dataset is a topologically correct network dataset which means it can be used with the
"network analyst" tool in ArcGIS to calculate "service areas" and show how far you can get
by car from specific points within specified times. A population dataset at the municipal level
is also used. This data is downloaded from Statistics Norway and is used in the analysis of
commuting patterns and to calculate population density.

All the data used in this thesis are spatial in nature, meaning the data has information
attached to it which geographically localises it on Earth. For the commuting data, the attribute
that localises it is the information about the BSU. This type of geographical data can be
stored, managed and processed through a geographical information system (GIS). A GIS is a
software that improves the efficiency and effectiveness of handling and visualising
information about geographic objects and events and solve geographic problems (Longley et
al. 2011). The software ArcGIS by ESRI is the main GIS used in this thesis.

The geographic data used in this thesis are in vector format. Vector is one of two ways
a GIS represents geographic information, raster being the other way. Vector data represents
geographic data as discrete objects made up of points, lines, or polygons, which are a series of
points connected by straight lines, while raster represents geographic data as continuous fields
(Longley et al. 2011). For example, each BSU is represented as a polygon in the dataset of
BSUs.

### 3.2.2 Reliability and validity

In this section, the reliability and validity of the data will be discussed. The reliability refers to
the quality of the data and whether or not the data is of high enough quality that doing the
analysis several times will yield the same results (Skog 2004). A concept tightly linked with
reliability is uncertainty. Uncertainty is the difference between the contents of a dataset, and
the real-world phenomena the data represents (Longley et al 2011). When using geographic
data there is always uncertainty in the data because the world is infinitely complex, and
computers are finite. The real world is just too complicated to model accurately to a full
extent in a GIS, and representations of the geographic phenomena in a GIS are thus always
incomplete (Longley et al. 2011). This becomes clear when using vector data.

With vector data, internal variation within a point, line or polygon cannot be shown. Instead, the variation is aggregated. Both vector and raster data do not account for the
limitations of computers in modelling the real world and will, for example, have generalised
borders and boundaries (Longley et al 2011). This is a limitation not much can be done about except for being aware of the limitation and to consider how it can impact the results of the analysis. In this thesis, the data limits the lowest scale used to the BSU, so any variation within a BSU cannot be shown. The next possible lower level of scale would be coordinates for home and work place. With this, it would be possible to see exactly where people were commuting to in each regional city. Data with this high level of detail is not possible to get a hold of due to the possibility of individuals in the dataset being identifiable, but it is not necessary for this thesis anyway. The level of detail in the data available is sufficient as the interesting information is commuting patterns to the specific regional cities over time. To answer the research question, it is not necessary to see exactly where people are commuting to, only which BSU and if that BSU is part of a regional city. This limitation will therefore not impact the results in any noticeable way. Similarly, population data at the BSU level is sufficient as it is of high enough detail to limit the selection to the population within the regional cities and not the entire municipality.

Another source of uncertainty in the data is the fact that all the data used are secondary data. Secondary data is information that has been collected by someone else, distinct from primary data which is collected by the researcher themselves (Flowerdew & Martin 2005). The use of secondary data presents several potential problems, according to Flowerdew & Martin (2005). The data is inflexible, its quality is unverifiable by the research themselves, and the data is a cultural artefact produced by someone else. It is therefore important to be aware of where data is from and to consider how reliable the source is.

The main dataset of commuting statistics used in this analysis could potentially have errors in it. The sources of error can be human or come from the various registries the statistics are collected from. For example, the uncertainty inherent in the Aa-registry will be carried on to the commuting dataset. It is, however, likely that errors in this dataset will be small in extent and will not have any noticeable impact overall on the results. The same applies for the population dataset. Any errors would in this dataset would most likely be so small they would be negligible. The source for both of these datasets, Statistics Norway, can reasonably be considered a very reliable and neutral data source that provides data of high accuracy. The Norwegian Mapping Authority can also reasonable be considered to be a very reliable and neutral source of geographic data.

Another issue related to uncertainty is how representative a data sample is for the population. Can the data sample be generalised and yield results that are valid for the whole
population? A big advantage of the commuting dataset used in this thesis is that it is from a registry, meaning the data includes the whole population studied and not a sample of the population. It should include every person living and working in the Greater Oslo Region. The issue of representativeness is therefore non-existent in this analysis. If the dataset was a limited sample of the full data, the sample's representativeness for the whole population would have to be considered along with the uncertainty of the results. With a dataset for the entire target population, there is no uncertainty about its representativeness.

There are several types of validity that need to be considered. The construct validity of the data refers to how well the data is suited to measure the phenomena of interest. The question in a context of construct validity is then if the data variables used in this analysis actually measure urban structure and specifically polycentricity sufficiently. Does the development of population measure the development of morphological polycentricity? Do the variables in the commuting dataset measure commuting patterns, and does the evolution of commuting patterns measure the evolution of functional polycentricity?

There are no direct or perfect indicators of polycentricity; the phenomena polycentricity itself cannot be measured. Only indirect indicators that have a perceived link to polycentricity exist. How good the linkage is between the indicator and polycentricity is subjective, and this creates ambiguity that can lead errors. Systematic errors of measurement can arise if the indicators do not measure the phenomena after all (Longley et al. 2011).

It is clear polycentricity is difficult to measure accurately, as discussed briefly in the theory chapter. Several indicators of polycentricity have been used to measure it, like population size, employment size and density (Burger et al. 2011), the built environment (Taubenböck et al 2017), commuting trips and other types of daily mobility (Vasanen 2012), flows of goods, services, capital, information, waste, assets, pollution, water and other environmental resources (Davoudi 2008), and knowledge linkages (Li & Phelps 2018). Using measures on employment, like size, density and distribution, and/or commuting trips are a very common way of measuring polycentricity, and especially common for measuring functional polycentricity. When measuring morphological polycentricity, population size and/or density stands out as a natural choice because the aim is to measure and compare the size of the centres that make up the urban area or the cities that make up the region.

The following are some examples of studies using population and commuting patterns to measure polycentricity or urban structure: De Goei et al. (2010) used commuting patterns to measure the development of functional polycentrism in the Greater South East United
Kingdom between 1981 and 2001, Champion and Coombes (2012) used commuting patterns to measure the development of polycentricism in the Pennine urban system (Manchester, Liverpool, Preston, Leeds, Sheffield). Grunfelder et al. (2015) use population, employment and commuting indicators to measure polycentricity in Denmark, Modarres (2011) investigates commuting patterns and population in relation to polycentricity in Southern California, Zhao et al. (2016) use commuting patterns to show that the Munich metropolitan region is developing towards polycentricity from monocentricity, Cats et al. (2015) use public transport passenger flow data to measure the urban structure of Stockholm and show that a polycentric structure has not been realised so far despite it being a planning policy goal for the city, and finally, Limtanakool et al. (2009) use commuting data to measure the change in configuration for 23 Dutch Urban systems. It is evident that measuring polycentricity and urban structure by using commuting as an indicator is an established method.

Commuting is seemingly a commonly used indicator to measure polycentricity. Commuting patterns are strongly correlated with the urban structure and specifically the location of jobs and housing, although other factors also impact commuting behaviour (Lin et al 2015). Because commuting patterns reflect the urban structure so well, they are also a very good indicator of polycentricity and a good fit for measuring the development of polycentricity in the Greater Oslo Region.

Ideally, as many relevant indicators as possible would be used instead of just one single indicator. For example, population and employment data, information about non-work related trips in the region like shopping trips, inter-firm trade, flows of money and information, knowledge, services, goods, assets, and waste (Davoudi 2003, Burger et al. 2014). Combined these would give a complete picture of the functional linkages in the city and give a better indication of polycentricity. Commuting on its own, however, does tell a good story about a region. Commuting shows us where people are regularly travelling to and where economic activity is concentrated in the region. It is one of the main functional linkages in a region and is a good indication of how the region functions on a daily basis and thus the regions functional urban structure. Commuting is also a very visible functional linkage, that has a significant impact on society at large (Horner 2004).

The internal validity refers to whether any causal conclusions can be made about the independent variables affecting the values of the dependent variables (Skog 2004). In this thesis, causality is not examined. The research question is not asking why the greater Oslo region has or has not become more polycentric, and therefore the question of internal validity
is not relevant. External validity refers to whether the results can be generalised to other contexts and situations (Skog 2004). The results of this study on the polycentric evolution of the Greater Oslo Region will not be able to tell us anything about the polycentric evolution of other urban regions in Norway or outside Norway as the causal reasons behind the development are beyond the scope of this thesis. Therefore, the external validity of this analysis is very low.

3.3 Methodology

The next part will discuss the methodology used in this thesis in detail from data preparation to analysis. The main tools used in this thesis is the geographic information system ArcGIS, the statistics software SPSS Statistics, and Microsoft Excel. These were used in combination to prepare, manage and analyse the data, and present the results.

The methodology used to find out if the Greater Oslo Region has become less or more polycentric between 2001-2015 is a relatively simple temporal spatial analysis of the evolution of commuting to the specific regional cities, the employment centres in Oslo, and Oslo municipality, relative to the change in the total population for the Greater Oslo Region. For each year of available commuting data, the number of commuters to the BSUs that make up a specific regional city, the BSUs that make up a specific employment centre, and Oslo municipality is divided by the total population in the Greater Oslo Region for that year and multiplied by 100. The result is a percentage of how many people in the Greater Oslo Region commute to the regional cities, employment centres in Oslo, and Oslo municipality for each year. With this the evolution of commuting to each of the regional cities can be compared to the commuting to Oslo municipality and the employment centres in Oslo, and the average change from 2001 to 2015 for all the regional cities together, the employment centres together, and Oslo municipality can be calculated.

The following section will describe the methodology in more detail. With the data in hand, the first step is to prepare it for analysis. The geographic dataset containing the BSUs is prepared using ArcGIS. All BSUs outside the Greater Oslo Region are deleted from the dataset to make the dataset easier to work with and faster to process for the software. This is done using the "select by attributes" function. Then, in the dataset containing population data at the BSU level, all BSUs outside the Greater Oslo Region are deleted, as well as any row where the BSU is undisclosed. These are rows of data that are not needed. These two datasets
are then joined using the "spatial join" function in ArcGIS. The result is a layer with population for every BSU in Eastern Norway from 2000 to 2016.

It is important to see if there have been any changes to the relevant BSUs during the study period. BSUs are from time to time split up, joined together, redrawn, or deleted and replaced by new BSUs Statistics Norway. The BSU of Snarøya, which covered the old Fornebu airport, was split into 20 new BSUs in 2013. This was accounted for by using all of the BSUs from before 2013 and all after, which then accounts for all the years. In Lillestrøm, one BSU was replaced by two new BSUS in 2013. By selecting all three of them all years will still be accounted for. There are no BSUs that are used which have been redrawn in the study period. This makes analysing the changes in ratio of commuting to the BSUs much easier.

With the BSU layer ready, the next step is to select which BSUs make up each regional city and employment centre in Oslo. The geographic dataset of continuous urban areas (tettsteder) is imported into ArcGIS to act as a guide. The regional cities are made up of a selection of basic statistical units (grunnkretser) that try to reflect the regional cities' boundaries. The selection of which BSUs make up the regional cities is based on the name of the BSU, the continuous urban areas layer, aerial photography, zoning plans from the relevant municipalities, and Google Maps. The main goal is to select the BSUs so as much of the continuous urban area as possible is covered by the selection. In Lillestrøm, Ås, Ski and Jessheim, the BSUs on the edge of the city expand considerably further out than the continuous urban area. In these cases, the BSUs are included in the selection even if they only cover a sliver of the continuous urban area. This is to ensure that the regional cities don't have important parts that are left out as the selection will be the basis for the analysis of population development and commuting patterns. Omitting a BSU on the edge of a city could potentially be the exclusion of a significant residential area or workplace meaning the people living in that BSU or the commuters to that BSU will then be omitted from the analysis of population and commuting to the specific regional city. This would make the results of the analysis less accurate. For Jessheim specifically, The BSU that covers the very large workplace of Oslo airport is omitted as the airport is not part of the regional city. The regional cities of Sandvika and Asker are both within the continuous urban area Oslo, and the BSUs that cover them are thus more difficult to select as accurately. As with the other regional cities, there are no official city boundaries for Asker and Sandvika. And while the other cities were not surrounded by continuous urban area meaning there was a clear indication of where the boundaries of the cities ended, this is not the case for Sandvika and Asker.
Sandvika and Asker are both completely surrounded by the continuous urban area of Oslo. For these two regional cities, the focus is therefore on selecting the core where the majority of workplaces are located and to not exceed the selection beyond the city because this could artificially increase the number of commuters to these cities. Google Maps, aerial photography and zoning plans were especially useful for identifying where the industrial areas and workplaces are and where the largely residential areas begin.

A different selection will be used for analysing the population development in Asker and Sandvika. Here a 2-kilometre buffer around the most central BSU, the core of the regional city, is created and used as a guide for selecting the BSUs. This is to ensure that residential areas are also included so most of the population isn’t excluded because most live outside the commercial core. A 2-kilometre buffer roughly matches the radius from centre to the BSUs on the edge for the other regional cities and matches the buffer around the regional cities in figure 1, the map from the Regional Plan for Land Use and Transport in Oslo and Akershus (Plansamarbeidet 2015). Using a 2-kilometre buffer ensures the selection between these two and the other cities is consistent. For the other cities the same selection is used for

Figure 3.2: Example of lack of overlap between BSU and continuous urban area in Lillestrøm. Black lines indicate the BSUs, with the continuous urban area marked in red.
analysing population and commuting because the selection of BSUs covers most of the continuous urban area.

The same issue presents itself when selecting the BSUs for the employment centres within Oslo. For these, the focus is also on selecting the core. The 9 employment centres selected are Fornebu, Lysaker, Skøyen, Blindern-Forskningsparken-Marienlyst, Majorstuen, Oslo sentrum (city centre), Nydalen-Storo, Økern, and Ensjø-Helsfyr-Bryn. These are all located in Oslo municipality, except for Fornebu and Lysaker which are in Bærum municipality.

The way the BSUs are selected means the modifiable areal unit problem (MAUP) might be a problem. The MAUP is a problem when data is at the level of zones instead of individuals and the results of an analysis are sensitive to the ways the zones are selected; the way the space is partitioned, as well as the scale used (Longley et al. 2011, Flowerdew & Martin 2005). As the scale is kept constant at the BSU level, the scale part of MAUP should not be a problem. The selection on the other hand does have the potential to affect the results as there are so many different ways of selecting the BSUs. As mentioned, the selection does have the potential to artificially increase the number of commuters to a regional city if the selection of BSUs is extended outside the regional city, or the selection could exclude certain BSUs that are part of the of the regional city, reducing the number of commuters to that city. However, by consistently sticking to the method of selection and selecting the BSUs that encompass the work places that are clearly within a regional city, the results should not be affected. When the focus is on selecting BSUs that clearly contain work places, the omission of a BSU which belongs to the regional city should not have much effect as the BSU should largely be residential and there should thus be no impact on the calculation of number of commuters to the regional city. Other than this, there is little to be done about the MAUP except being aware of it (Flowerdew & Martin 2005).

After selecting all the BSUs, the next step is to prepare and analyse the population data. First, using the dataset for population for every BSU in the Greater Oslo Region, the total population in the region for each year between 2001 and 2015 is calculated by summarising the population of all the BSUs. Then the change in population between 2015 and 2001 is calculated along with the total percentage change, and annual growth rate using the formula for annual growth rate. The annual growth rate is the average percentage increase of the population each year from 2001 to 2015. After this, the total population of every regional city, the total for the regional cities combined, and the city of Oslo is calculated in the same
way using the annual growth rate formula, where n is 14, the number of years between 2001 and 2015:

\[ 100 \times \left( \frac{n \sqrt[2]{\text{population}_{time2}}}{\text{population}_{time1}} - 1 \right) \]

After this, the preparation for analysing the origin-destination commuting dataset to find out how many people commute to each regional city and employment centre for each year can be started. First, every row with commuting to or from a BSU outside the Greater Oslo Region is deleted from the dataset using the "select cases" function. Rows with commuting from within a regional city to the same regional city, or same employment centres, are included in the selection. As well as rows with commuting from and to the same BSU. This is because the definition of commuting used is any regular travel from place of residence to workplace. Travel to work within the same BSU is thus considered commuting and would count as commuting to the specified regional city or employment centre. This ensures that the results are not affected by people who move to the same BSU as they work in after 2001. If this happens and commuting to a BSU was only counted as trips to work from a different BSU, it would be counted as a loss of one commuter and worker in that regional city despite them still working in the same BSU as before. The number of commuters to, for instance, a regional city is then actually the number of people who live in in the Greater Oslo Region and work in a BSU that is part of that specific regional city.

Each BSU has a unique identification number, the BSU ID. This number also identifies which municipality it is in. These identification numbers are used to select the rows with commuting to the BSUs for each city and employment centre. Commuting to each of these are selected and separately exported to new datasets, one for each regional city and employment centre. Each dataset then contains the number of commuters from every BSU in the Greater Oslo Region to the regional city, employment centre or Oslo municipality. Each dataset is exported to an excel spreadsheet where the total number of commuters to each regional city and employment centre, and to Oslo municipality is summarised for the year of 2001, 2007, 2008, 2010, 2011, 2012, 2013, 2014, and 2015.

While the development of the number of commuters is interesting in itself and shows the difference in functional size and the development of the functional size, to see if Oslo
municipality or the regional cities have had the biggest relative increase or decrease compared to each other, the percentage of the total population of the Greater Oslo Region that commute to Oslo municipality and the regional cities is also calculated. Doing this allows us to see if the relative increase or decrease of commuting is larger and thus if Oslo or the regional cities have attracted more workers. If the regional cities have had a bigger increase than Oslo in percentage of the population that commute to them, then that is a clear indication the region has developed towards functional polycentricity.

4 years with approximately the similar time between them are also selected, 2001, 2007, 2011, and 2015, creating 3 periods of time. The change in commuting between these years for each regional city, each employment centre in Oslo and Oslo municipality is calculated. Then the per cent of the total population in the Greater Oslo Region who commute to each is calculated, and then the change in percentage points between the years. The averages for the regional cities and employment centres is also calculated. Selecting 4 years in addition makes it possible to see the fluctuation between the years opposed to just the change between 2001 and 2015.

In addition to seeing the change in where people commute to, where people commute from is also calculated and visualised for 2001 and 2015. This is done by summarising the number of commuters from each municipality to the BSUs that make up the regional cities using the "consolidate data" function in Excel. The municipalities are used as origin instead of the BSUs because it creates a more comprehensible map. Then the spreadsheet is spatially joined with a layer of the municipalities in GIS and the number of commuters for 2015 from each municipality is normalised by the population in that municipality for the same year. This is also done for 2001. This results in choropleth maps that visualise the per cent of the municipal population that commute from each municipality in the region, to each regional city for the year 2001 and 2015. Two maps are produced for each regional city and Oslo municipality and presented side by side for easier comparison.

The classification of the data ranges for the two choropleth maps must be the same so that a comparison can be made. The natural jenk classification is used to classify the data. This classification calculates the natural breaks in the data by minimising variance within classes and maximising variance between classes (Longley et al. 2001). A total of 6 classes are used. The natural jenk classification for 2001 is used for the 2015 version of the same city as well. By doing this, any changes in the way the data is classified between 2001 and 2015, due to changes in the data between the two years, will not have any effect on how the map
looks. The two maps for each city visualise if there has been any change in which municipalities people commute from and makes it possible to compare the change in commuting origin between Oslo and the regional cities.

The analysis done in this thesis is a quantitative analysis and is also temporal and spatial in nature. A quantitative analysis is best suited to answer the research question because the commuting patterns are patterns on a large scale. The main analysis is a temporal and spatial analysis of population data and commuting patterns. A spatial analysis is the process in which transformations, manipulations, and methods are applied to geographic data to add value to them and reveal patterns and anomalies that are not obvious. The analysis turns raw data into useful information (Longley et al. 2011). In this analysis, ArcGIS is primarily used to manage and prepare the data and present the results in maps. The preparation of the data and presentation of the results involves several spatial analyses. GIS is especially useful for visualising the complex data of where people commute from. Creating a map visualisation of the very large commuting dataset by creating choropleth map transforms the raw commuting data into information that is digestible.

Figure 4.3 is made using a network analysis of a topologically correct road network dataset. This is done using the "network analyst" tool in ArcGIS to create a new service area layer. Figure 4.4 is made by normalising the population by the area for each municipality and symbolising the results to make a choropleth map.

The results of the analysis are descriptive. The thesis is not asking any questions about causality and therefore no causal analysis is done, and nothing can be said about why the region has become less or more polycentric.
4 Results

4.1 Context

The Greater Oslo Region has several regional cities and centres. The regional cities studied in this thesis are Asker, Jessheim, Lillestrøm, Sandvika, Ski, and Ås. These are, as mentioned, the prioritised growth areas in Oslo and Akershus in addition to Oslo, according to the Regional Plan for Land Use and Transport in Oslo and Akershus (Plansamarbeidet 2015).

The regional cities studied have all existed as smaller towns that have developed and become part of the expanded urban region. Asker and Sandvika are located west of Oslo and have established business environments. They are both part of a geographic area stretching west to Kongsberg, with many businesses in the technology sector (teknologiaksen). Asker is the administrative centre and largest town in Asker municipality, while Sandvika is the administrative centre and largest city in Bærum municipality. Lillestrøm is a 10 minute train trip east of Oslo. This regional city has a concentration of businesses in research and technology, life sciences, and advanced logistics. Lillestrøm is the administrative centre and largest city in Skedsmo municipality. Jessheim is northeast of Oslo and is located close to Oslo airport, which it benefits from. The city is planning to increase the amount of businesses in the city. Jessheim is the administrative centre and largest city in Ullensaker municipality. Ski and Ås are located southeast of Oslo. Ski has development potential the commerce and services sector. The Norwegian University of Life Sciences is located in Ås, so Ås naturally has the potential to develop further as a hub for life sciences (Plansamarbeidet 2015). Ås and Ski are the administrative centres and largest town of their respective municipalities of the same name. Asker, Ski and Ås are not officially cities but rather towns or urban settlements. However, for simplicity's sake, they will be referred to as regional cities in this thesis, like they are in the regional plan.

Of the regional cities studied, Asker, Sandvika and Lillestrøm are part of the continuous urban area of Oslo, these are part of the internal structure of the city. Jessheim, Ski and Ås, on the other hand, are located outside the continuous urban area of Oslo. Land that cannot be characterised as urban separate them from Oslo. Therefore, this study will be at the inter-urban scale. In addition, further clarifying which scale the polycentric development is studied at, commuting to the regional cities and Oslo from the entire Greater Oslo Region are
analysed opposed to commuting only from within the continuous urban area of Oslo or the municipality of Oslo.

**Figure 4.1**: Map showing the selection of the BSUs that make up regional cities with continuous urban area beneath.
In addition to the regional cities, a selection of employment centres within the continuous urban area of Oslo have been selected to be used as a comparison and to get a better picture of where in Oslo people commute to. These employment centres are, from west to east: Fornebu, Lysaker, Skøyen, Blindern-Forskningsparken-Marienlyst, Majorstuen, Oslo sentrum/city centre, Nydalen-Storo, Økern, and Ensjø-Helsfyr-Bryn.

Figure 4.3 shows how long it takes to drive from the very centre of Oslo to the various parts of the Greater Oslo Region. This map provides a clearer picture of the size of the region. All the regional cities studied are within a 45 minute drive from Oslo. Some of the regional cities do have a considerable greater distance between them, like Jessheim and Ås, and Jessheim and Asker, making commuting between these cities less likely. Overall, the regional cities are well covered by the motorway network in the region as well as the railroad network, which can match travel times by car. The continuous urban area of Oslo is mostly within a 15 minute drive from the starting point, with some parts in the west being closer to a 25-30 minute drive, like Asker. The outer edges of the region are mostly within a 75 and 90 minute drive. The regional cities are close enough to be considered geographically clustered, opposed to randomly distributed, since the neighbouring cities are within 1 hour driving from each other. At the same time, the regional cities do not form a continuous urban region since there is a clear separation between them. In other words, the regional cities are distributed in a way that gives the region potential for being a PUR and thus a good case to study.
Figure 4.3: Driving times in the Greater Oslo Region from Oslo city centre.
4.2 Analysis of population

This section will present the results of the analysis of population to see if the region has become more morphologically polycentric between 2001 and 2015. The section after will present the results of the analysis of commuting patterns to see if the region has become more functionally polycentric.

Figure 4.4 shows the population density in the Greater Oslo Region at a municipal scale level for 2015. Oslo municipality has the by far highest population size with 647 676 people living there in 2015 and a density of 1333 people per square kilometre. The bordering municipalities of Bærum, Lørenskog, Skedsmo and Oppegård, along with Asker, Drammen and Askim have the second highest population density, between 455 and 711 people per square kilometre. Bærum has a density of 559 people per square kilometre and a population of 120 685, Asker municipality has a density of 458 people per square kilometre and a population of 59 571, and Skedsmo 689 people per square kilometre and a population of 51 725 people. Ski and Ås municipality have a very similar density. Ski has a density of 180 people with a population of 29 775 people and Ås 177 people per square kilometre with a population of 18 503 people. Ullensaker has the lowest population density with a density of 132 people per square kilometre, just shy of Ski and Ås. The population in Ullensaker is 33 310.
Figure 4.4: The regional cities, and Oslo, with population density at a municipal level in 2015 and continuous urban areas in red underneath.
The population in the Greater Oslo region has been rising in the study period between 2001 and 2015. From figure 4.5 one can see that the rate of growth increased slightly around 2006-2007. The population has increased from 1.25 million in 2001 to 1.55 million in 2015, a growth of 23.9 per cent and an annual growth rate of 1.59% in the 14 year period. The region has for parts of this period been in the list of the top 5 fastest growing urban regions in Europe (Wessel & Barstad 2016).

Figure 4.6: Population in the Greater Oslo Region from 2001 to 2015.

Figure 4.5: Population in Oslo municipality from 2001 to 2015.
Around 175,000 people have been added to the continuous urban area of Oslo (tettstedet Oslo). Oslo municipality has grown from 508,726 people in 2001 to 647,676 people in 2015. Out of the total growth of 297,905 people in the region, 46 per cent of it was in Oslo municipality, while 60 per cent of it was in the continuous urban area of Oslo.

The regional cities have experienced a total growth of 24,765 people combined between 2001 and 2015, from 92,908 to 117,667 people. A growth of around 39 per cent. The population growth in number of people is clearly a lot smaller than Oslo municipality, as expected.

Although the growth in number of people is clearly higher for Oslo, the change in percentage and the annual growth rate has been roughly similar in the regional cities combined. The per cent change in Oslo municipality has been 27.31 per cent and the annual growth has been 1.82 per cent from 2001 to 2015 (see figure 4.6). For the regional cities combined, the change in all the regional cities summarised, the per cent change has been 26.66 per cent and the annual growth rate has been 1.78 per cent. For the Greater Oslo Region in total, the per cent change has been 23.86 per cent and the annual growth has been 1.59 per cent. The growth has thus been a tiny bit slower and the change measured in per cent a bit smaller in the regional cities than in the municipality of Oslo but the growth has been faster and larger than the Greater Oslo Region as a whole. The difference between the change in percentage between Oslo and the regional cities combined is 0.65 percentage points and the difference in annual growth rate is 0.04 percentage points.
Figure 4.8 shows the population for each regional city in 2001 and 2015 and table 4.1 shows the change, per cent change, and annual growth rate for each regional city and Oslo municipality, the cities combined, and the average for the regional cities. Jessheim is the regional city with the largest amount of growth in population with a growth of 70.39 per cent and an annual growth rate of 3.88 per cent. Lillestrøm (including Kjeller) is second in population with a growth of 35.49 per cent and an annual growth rate of 2.19 per cent. Ås has had a growth of 28.73 per cent and an annual growth rate of 1.82 per cent. Ski has had a

As is evident, Asker and Sandvika, the only two regional cities surrounded by the continuous urban area of Oslo have grown the least of all the regional cities. Compared to the municipalities as a whole, Asker municipality has grown from 49 661 people to 59 571, a change of 19.96 per cent and an annual growth rate of 1.33 per cent, indicating that a lot of the new population in the municipality has settled outside the 2-kilometre buffer from the core which makes up the regional city. In Bærum municipality, the population has grown from 101 340 to 120 685, a 19.09 per cent change and an annual growth rate of 1.26 per cent. Higher than Sandvika, but again, lower than the other regional cities. Both Asker and Bærum consist of large suburban residential areas which in this thesis does not count as being part of the regional cities.
Table 4.1: Population in the regional cities and Oslo municipality in 2001 and 2015, and change between 2001 and 2015 in number of people, per cent and the annual growth rate. With total and average calculated for regional cities.

<table>
<thead>
<tr>
<th>City</th>
<th>2001</th>
<th>2015</th>
<th>Change</th>
<th>Per cent change</th>
<th>Annual growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asker</td>
<td>22 893</td>
<td>25 797</td>
<td>2 904</td>
<td>12.69 %</td>
<td>0.86 %</td>
</tr>
<tr>
<td>Sandvika</td>
<td>23 834</td>
<td>27 446</td>
<td>3 612</td>
<td>15.15 %</td>
<td>1.01 %</td>
</tr>
<tr>
<td>Ski</td>
<td>11 902</td>
<td>14 498</td>
<td>2 596</td>
<td>21.81 %</td>
<td>1.42 %</td>
</tr>
<tr>
<td>Ås</td>
<td>7 690</td>
<td>9 899</td>
<td>2 209</td>
<td>28.73 %</td>
<td>1.82 %</td>
</tr>
<tr>
<td>Lillestrøm</td>
<td>15 093</td>
<td>20 449</td>
<td>5 356</td>
<td>35.49 %</td>
<td>2.19 %</td>
</tr>
<tr>
<td>Jessheim</td>
<td>11 490</td>
<td>19 578</td>
<td>8 088</td>
<td>70.39 %</td>
<td>3.88 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>92 902</td>
<td>117 667</td>
<td>24 765</td>
<td>26.66 %</td>
<td>1.70 %</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>15 484</td>
<td>19 611</td>
<td>4 128</td>
<td>30.71 %</td>
<td>1.86 %</td>
</tr>
<tr>
<td><strong>Oslo</strong></td>
<td>508 726</td>
<td>647 676</td>
<td>138 950</td>
<td>27.31 %</td>
<td>1.74 %</td>
</tr>
</tbody>
</table>

The average change in per cent for the regional cities is 30.71 per cent, higher than the change for Oslo municipality. This is, however, in large part due to Jessheim's very high growth and Lillestrøm's high growth. The average annual growth rate for the regional cities is 1.86 per cent, also in large part due to Jessheim and Lillestrøm. Together with Ås, these three regional cities all have a bigger growth in per cent and a higher annual growth rate than Oslo municipality. Ski is the only regional city outside the continuous urban area of Oslo with a lower growth in per cent and a smaller annual growth rate than Oslo.

4.3 Analysis of commuting patterns

The analysis of the development of commuting patterns in the Greater Oslo Region between 2001-2015 will tell us if the region has become more functionally polycentric. The results from the analysis will show the amount of people commuting to each of the regional cities, Oslo municipality, and the employment centres in Oslo as a percentage of the total population in the region for each year of available data. This will show if the regional cities have attracted more commuters compared to Oslo and thus if there is an indication that the region has become more functionally polycentric.
The amount of people commuting to the regional cities has gone up between 2001 and 2015 for every regional city except for Sandvika. In Sandvika, the number of commuters rose up until 2011 where it topped out at 13 035 people, before fluctuating and finally settling at 11 104 in 2015, 167 commuters less than in 2001. For the cities where the number of commuters has increased, the rise has been relatively steady most years with some fluctuation between a few years. The city with the most commuters to it in 2015 is Lillestrøm, and Jessheim second with around 2 000 less commuters. Ås is the regional city with the lowest number of commuters to it, as well as the most modest increase of the cities that had an increase. For all the regional cities together, the total increase of commuters is 17 332 people, a change of 39.24 per cent from 2001 to 2015.

![Number of commuters to the regional cities 2001-2015 from the Greater Oslo Region.](image)

Figure 4.9: Number of commuters to the regional cities 2001-2015 from the Greater Oslo Region.

For Oslo municipality, the number of commuters to the municipality has gone up from 336 602 in 2001, to 396 369 in 2015, an increase of 59 767 people. There has been an increase in number of commuters each year of available data. As expected, none of the regional cities can match the numbers of commuters to Oslo in number of people.
Figure 4.12 shows the percentage of the population in the Greater Oslo Region that commute to each of the regional cities for each year of available data between 2001 and 2015. All of the regional cities except Sandvika and Ås have had an increase in the share of the population that commutes to them. Ås has the lowest share of the population commuting to BSUs in the regional city, with 0.287 per cent in 2015, down from 0.336 per cent in 2001. Asker is up from 0.399 per cent in 2001 to 0.521 per cent in 2015, the second lowest amount. Ski has been relatively stable with a slight increase from 0.537 per cent to 0.587 per cent. Sandvika has decreased from having the highest percentage in 2001 of 0.903 per cent but decreased to 0.718 per cent in 2015, a change of -0.185 percentage points. The decrease started after a high of 0.904 per cent in 2011. This is the largest decrease. Jessheim started out as the second lowest in 2001 with 0.376 per cent of the population commuting to the city but in 2015 has the second highest percentage with 0.799 per cent, the biggest increase. Lillestrøm has the highest percentage of the population commuting to a BSU in the city, from 0.826 per cent in 2001 to 0.971 in 2007, then down to 0.934 per cent in 2015.
Summing the percentages for each regional city results in the total percentage for all the regional cities. Figure 4.11 shows how the percentage has increased by 0.469 per cent from 2001 to 2015. There was a relatively big increase of 0.220 per cent during the 6 year period from 2001 to 2007, indicating a steady increase similar to the period from 2008 to 2014. From
2014 to 2015, the percentage decreased from 3.938 per cent to 3.846 per cent, a decrease of 0.092 per cent.

While the number of commuters to BSUs in Oslo municipality increased from 2001 to 2015 by 59,767 people, the percentage of the total population of the Greater Oslo Region that commutes to a BSU in Oslo municipality decreased.

The share of the population commuting to Oslo municipality was 26.954 per cent in 2001. It steadily decreased to 25.849 per cent in 2010, then rose to 25.948 per cent in 2011 and was relatively stable until a rise to 25.999 per cent in 2014. It decreased to 25.627 per cent in 2015, the lowest percentage of the period.

Table 4.2 shows the change in percentage points between the share of the population that commutes to each of the regional cities and Oslo municipality from 2001 to 2007, 2007 to 2011, and 2011 to 2015, in total 3 periods.

![Graph showing the percentage of the Greater Oslo Region population that commutes to Oslo municipality from 2001 to 2015.](image)

**Figure 4.13**: Percentage of the Greater Oslo Region population that commutes to Oslo municipality.

On average, the regional cities have an increase in share of the population in the Greater Oslo Region that commutes to them for every period. The average percentage in 2001 is 0.563, with an average increase of 0.037 to 2007, then a smaller average increase of 0.018 to 2011, and an increase of 0.024 to 2015. The average change for the regional cities from 2001 to 2015 is 0.078 percentage points. For the regional cities in total, the percentage also increased for every of the 3 periods. Oslo municipality on the other hand had a decrease in percentage for every of the periods. From 26.954 in 2001, a decrease of 0.291 to 2007, a
larger decrease of 0.714 to 2011, and finally a decrease of 0.322 to 2015. With a total decrease of -1.327 from 2001 to 2015.

Table 4.2: Percentage point change from 2001 to 2007, 2007 to 2011, and 2011 to 2015 for regional cities and Oslo municipality. Including average and total for the regional cities.

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Lillestrøm</td>
<td>0.826</td>
<td>0.144</td>
<td>-0.059</td>
<td>0.023</td>
<td>0.108</td>
<td>0.934</td>
</tr>
<tr>
<td>Jessheim</td>
<td>0.376</td>
<td>0.094</td>
<td>0.063</td>
<td>0.265</td>
<td>0.422</td>
<td>0.799</td>
</tr>
<tr>
<td>Sandvika</td>
<td>0.903</td>
<td>-0.028</td>
<td>0.029</td>
<td>-0.186</td>
<td>-0.185</td>
<td>0.718</td>
</tr>
<tr>
<td>Ås</td>
<td>0.336</td>
<td>-0.097</td>
<td>0.066</td>
<td>-0.019</td>
<td>-0.049</td>
<td>0.287</td>
</tr>
<tr>
<td>Ski</td>
<td>0.537</td>
<td>0.027</td>
<td>0.027</td>
<td>-0.003</td>
<td>0.050</td>
<td>0.587</td>
</tr>
<tr>
<td>Asker</td>
<td>0.399</td>
<td>0.079</td>
<td>-0.019</td>
<td>0.063</td>
<td>0.122</td>
<td>0.521</td>
</tr>
<tr>
<td>Total</td>
<td>3.377</td>
<td>0.220</td>
<td>0.106</td>
<td>0.143</td>
<td>0.469</td>
<td>3.846</td>
</tr>
<tr>
<td>Average</td>
<td>0.563</td>
<td>0.037</td>
<td>0.018</td>
<td>0.024</td>
<td>0.078</td>
<td>0.641</td>
</tr>
<tr>
<td>Oslo municipality</td>
<td>26.954</td>
<td>-0.291</td>
<td>-0.714</td>
<td>-0.322</td>
<td>-1.327</td>
<td>25.627</td>
</tr>
</tbody>
</table>

14.694 per cent of the population in the Greater Oslo Region commutes to the selected employment centres in 2015 (Table 4.3). Since 2001, the percentage has gone down by 0.387 per cent, from 15.081 per cent, a considerably smaller decrease than for Oslo municipality. Of all the commuting to Oslo municipality, the employment centres in Oslo (the selected employment centres excluding Fornebu and Lysaker) accounted for 48.99 per cent of the 25.627 per cent of the population in the Greater Oslo Region that commutes to the municipality; almost half of the commuting to Oslo municipality is to the employment centres. This indicates that most of the decrease in share of population that commute to Oslo has happened to other BSUs than those that make up the employment centres.

Oslo city centre has by far the largest number of commuters to it out of all the employment centres, but also the largest decrease with a decrease of -1.102 per cent, from 7.776 per cent to 6.674. Skøyen, Majorstuen, and Økern also had decreases, all around -0.1 per cent. Blindern-Forskningsparken-Marienlyst, Lysaker, Ensjø-Helsfyr-Bryn had moderate increases around 0.040 to 0.070 per cent, while Nydalen-Storo had a larger increase of 0.285 per cent. Fornebu had by far the largest increase, from 0.210 per cent to 0.868 per cent, an increase of 0.658 per cent. This is largely due to the development of the area as a hub for
technology companies and thus the development of many work places after the closure of Fornebu airport in 1998.

Table 4.3: Percentage point change from 2001 to 2007, 2007 to 2011, and 2011 to 2015, change from 2001 to 2015 and percentage in 2015 for selected employment centres in Oslo and Bærum. Including average and total.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Fornebu</td>
<td>0.210</td>
<td>0.311</td>
<td>0.116</td>
<td>0.230</td>
<td>0.658</td>
<td>0.868</td>
</tr>
<tr>
<td>Lysaker</td>
<td>1.223</td>
<td>0.044</td>
<td>-0.023</td>
<td>0.028</td>
<td>0.048</td>
<td>1.272</td>
</tr>
<tr>
<td>Skøyen</td>
<td>1.271</td>
<td>-0.090</td>
<td>-0.016</td>
<td>-0.050</td>
<td>-0.156</td>
<td>1.115</td>
</tr>
<tr>
<td>Blindern-F-M</td>
<td>0.842</td>
<td>0.097</td>
<td>-0.002</td>
<td>-0.032</td>
<td>0.062</td>
<td>0.905</td>
</tr>
<tr>
<td>Majorstuen</td>
<td>0.698</td>
<td>-0.042</td>
<td>-0.006</td>
<td>-0.075</td>
<td>-0.123</td>
<td>0.575</td>
</tr>
<tr>
<td>Oslo city centre</td>
<td>7.776</td>
<td>-0.839</td>
<td>-0.186</td>
<td>-0.076</td>
<td>-1.102</td>
<td>6.674</td>
</tr>
<tr>
<td>Nydalen-Storo</td>
<td>0.648</td>
<td>0.244</td>
<td>0.069</td>
<td>-0.028</td>
<td>0.285</td>
<td>0.933</td>
</tr>
<tr>
<td>Økern</td>
<td>1.228</td>
<td>0.167</td>
<td>-0.111</td>
<td>-0.184</td>
<td>-0.127</td>
<td>1.101</td>
</tr>
<tr>
<td>Ensjø-Helsfyr-Bryn</td>
<td>1.184</td>
<td>0.122</td>
<td>-0.011</td>
<td>-0.043</td>
<td>0.068</td>
<td>1.253</td>
</tr>
<tr>
<td>Total</td>
<td>15.081</td>
<td>0.013</td>
<td>-0.171</td>
<td>-0.230</td>
<td>-0.387</td>
<td>14.694</td>
</tr>
<tr>
<td>Average</td>
<td>1.676</td>
<td>0.001</td>
<td>-0.019</td>
<td>-0.026</td>
<td>-0.043</td>
<td>1.633</td>
</tr>
</tbody>
</table>

The next 7 pages show maps of the per cent of the population in each municipality that commute to each of the regional cities and Oslo municipality for 2001 and 2015. By comparing the 2001 to the 2015 map, it’s possible to see which municipalities in the Greater Oslo Region commuting as a per cent of population has increased or decreased from.

Figure 4.14 shows commuting to Lillestrøm. It is clear commuting to Lillestrøm is primarily concentrated on the east side of the region. Naturally, the highest share of the population that commute to Lillestrøm is from the closest surrounding municipalities. When comparing the two maps, it’s clear that none of the municipalities have had a visible decrease in the share of population that commute to Lillestrøm. Six municipalities, Hobøl, Oslo, Lørenskog, Nittedal, Lunner, and Eidsvoll, have had visible increases. Skedsmo, the municipality where Lillestrøm is located, has had a decrease from 9.35 per cent to 8.75 per cent.

Commuting to Jessheim is also concentrated around the eastern and north-eastern part of the Greater Oslo Region. There are five municipalities that show a visible decrease in per cent of population commuting to Jessheim from 2001 to 2015, namely those in the very south-eastern corner of the region. All the surrounding municipalities show a visible increase, as
well as several municipalities around the Oslofjord, even as far as Svelvik. Although the increases are quite small, the distance people commute to Jessheim has clearly extended. In total 28 municipalities had an increase in share of population that commute to Jessheim, the most of all the regional cities. In Ullensaker municipality, where Jessheim is, commuting increased from 12.35 per cent to 15 per cent to Jessheim.

For Sandvika, commuting is highly concentrated around the western part of the region and especially in the municipalities along the western side of the Oslofjord. Commuting to Sandvika decreased in several municipalities on the eastern side of the fjord, namely Gjerdrum, Lørenskog, Ski, Ås, Frogn, and Oppegård, as well as Hurum. While commuting increased only in two municipalities, Hof and Sande. Commuting from Bærum municipality to Sandvika decreased from 5.28 per cent to 4.14 per cent.

Ås municipality has commuting to it almost exclusively from the southern part of the region, on the eastern side of the Oslofjord. There is a visible increase in four municipalities from 2001 to 2015, on the edge of the area where commuting to Ås is concentrated. Only Ramskog municipality had a visible decrease in commuting to Ås. Commuting from Ås municipality to the regional city of Ås decreased from 15.93 per cent to 10.82 per cent.

Commuting to Ås, Ski has a more extensive increase in commuting to it from both surrounding municipalities and from those further away. All municipalities in the south-eastern part of the region as well as municipalities just east of Oslo have visible increases in share of population that commute to Ski. No municipalities have visible decreases. The share of population commuting from Ski municipality to the regional city of Ski decreased from 12.34 per cent to 10.95 per cent.

Commuting to Asker is, as Sandvika, concentrated around the western part of the region. In general, the percentages are lower than for other municipalities, with 4 out of 5 classes being under 2.14 per cent. Commuting to Asker decreased in 2 municipalities, Gjerdrum and Rømskog, while increasing in several municipalities all around the region. However, the increase are mostly from the first to the second class which is a very small increase from an already almost negligible percentage. The increases are a bit bigger around the western part of the region. Commuting from Asker municipality increased from 5.25 per cent to 5.47 per cent.

Oslo has, not surprisingly, the largest "reach" of all municipalities in the region, and municipalities have much higher percentages of people commuting to Oslo, with the lowest being 3.13% per cent in 2001. Commuting is highest in per cent around the surrounding
municipalities on the east side of the city, while also quite large from Asker and Bærum, which both have quite large populations. The very western parts and south-eastern parts have the lowest amount of commuting to Oslo. From 2001 to 2015, there are no municipalities that show a visible increase in per cent of population commuting to Oslo. 11 municipalities in total show a visible decrease in per cent commuting. These are located on the eastern side of the city, with most being the ones closer to Oslo, like Nesodden, Ski, Skedsmo, Rælingen, Enebakk and Ullensaker. The municipalities in the western side of the city have no visible change in per cent of population commuting to Oslo. Commuting from Oslo municipality to Oslo also decreased, from 46.17 per cent to 44.09 per cent.
Figure 4.14: Per cent of population in each municipality of the Greater Oslo Region commuting to Lillestrøm in 2001 and 2015
Figure 4.15: Per cent of population in each municipality of the Greater Oslo Region commuting to Jessheim in 2001 and 2015.
Figure 4.16: Per cent of population in each municipality of the Greater Oslo Region commuting to Sandvika in 2001 and 2015.
Figure 4.17: Per cent of population in each municipality of the Greater Oslo Region commuting to Ås in 2001 and 2015.
Figure 4.18: Per cent of population in each municipality of the Greater Oslo Region commuting to Ski in 2001 and 2015.
Figure 4.19: Per cent of population in each municipality of the Greater Oslo Region commuting to Asker in 2001 and 2015.
Figure 4.20: Per cent of population in each municipality of the Greater Oslo Region commuting to Oslo municipality in 2001 and 2015.
4.4 Discussion of results

The results from the analyses of the population and commuting data show if the Greater Oslo Region has developed towards a more morphological and functional polycentric urban structure from 2001 to 2015. The review in chapter 2 of what polycentricity is will be used to assess if the Greater Oslo Region has become more polycentric. Both the morphological and functional aspect of the polycentric development of the region is being studied, opposed to just one aspect of polycentricity. The most important aspect is whether or not the regional cities, acting as the subcentres of the region, have become more important parts of the region, in a morphological and functional sense, compared to Oslo, the dominant centre in the region.

To determine if the Greater Oslo Region has become more morphologically polycentric between 2001 and 2015, the results from the population analysis are used. If the population of regional cities have grown faster than the population of Oslo municipality, the regional cities can be said to have become more important in a morphological sense than Oslo from 2001 to 2015.

The population size and density in the municipalities of the Greater Oslo Region in 2015 show clearly that the region has an urban structure that is predominantly monocentric at an inter-urban scale. Oslo is by far the most dominant centre in the region when it comes to population size and density. The population in the regional cities, and even the municipalities, are not close to Oslo's population size of 647,676. A morphologically PUR is, as discussed, made up of several centres of roughly the same size that are located in the same urban system. The Greater Oslo Region is of course not completely monocentric because there are other centres located in the region in addition to Oslo, but it is safe to say the region is morphologically monocentric to a large degree. The question though, is if this monocentric structure has been sustained or if the structure developed towards polycentricity.

The results from the analysis of population growth show how the population in regional cities have grown compared to Oslo. If the population in the regional cities have grown more in percentage, and most importantly at a higher annual growth rate, i.e. faster, then that is a sign the urban structure has developed towards becoming more morphologically polycentric. The population of the regional cities combined do not indicate that the morphological monocentric structure of the Greater Oslo Region has changed significantly between 2001 and 2015. Because the regional cities combined have grown very similarly measured in per cent as Oslo municipality, only about 0.65 percentage points less, and the
annual growth rate has roughly been the same, the initial morphological monocentric structure has been sustained between 2001 and 2015 with no signs the status of Oslo as dominant centre has been reduced at all and no signs the regional cities combined are overtaking or even catching up to Oslo when it comes to population. The average per cent change and annual growth rate for the regional cities, however, is higher than for Oslo municipality. Jessheim is of course the main reason for the high average and it begs the question if conclusions for the regional cities together can be made using the average when half of the regional cities have a lower per cent change and annual growth rate than Oslo. There is significant difference between the different regional cities both in terms of per cent change and annual growth rate. While some of the regional cities have had a considerably faster annual growth than Oslo, namely Lillestrøm and especially Jessheim, Asker, Sandvika, and Ski have a lower per cent change and annual growth rate.

If Asker and Sandvika, which are both surrounded by the continuous urban area of Oslo, are excluded, the total per cent change and annual growth rate for the remaining four regional cities would be 39.52 per cent and 2.41 per cent, while the average would be 39.10 percent and 2.33 per cent. A larger growth in percentage and higher annual growth rate than Oslo municipality. This could indicate that the regional cities outside the continuous urban area of Oslo, and Lillestrøm on the very eastern edge of the continuous urban area, are slightly contributing to a more morphologically polycentric structure because all of them except Ski have been growing faster than Oslo.

Overall though, the regional cities have not grown more or faster than Oslo municipality and thus no conclusion can be made that the region has become more morphologically polycentric. Instead, for the regional cities overall the conclusion is that there is no sign the region has developed towards morphological polycentricity. But, since half of the regional cities have grown faster and have a higher per cent change this does indicate that some of the regional cities are contributing to a more morphologically polycentric structure in the region.

The results from the analysis of the commuting patterns show if the Greater Oslo Region has become more functionally polycentric between 2001 and 2015. If the regional cities have gained in the share of the Greater Oslo Region population that commute to them compared to Oslo municipality, the regional cities can be said to have increased their functional importance in the commuting network of the region and thus the region has become more functionally polycentric from 2001 to 2015.
Functionally, the region has a clear monocentric structure on an inter-urban scale where Oslo dominates in terms of functional importance and size both in 2001 and 2015. The per cent of the total population in the region that commute to Oslo was in 2015 25.627 per cent, over 20 per cent higher than the share that commute to the regional cities combined. The flow of people to Oslo is then much larger than to the regional cities. Oslo is evidently a much bigger employment centre and therefore a functionally more important and bigger centre. But, as Meijers (2007) points out, cities with at least a few hundred thousand inhabitants will qualify as being polycentric to an extent. This is also the case for the Greater Oslo Region and Oslo municipality. Since there is more than one employment centre in the region, and within Oslo municipality, there is a degree of polycentricity both at the inter-urban and intra-urban scale. Although, because of Oslo's dominance as a centre, the degree of polycentricity is very small.

The results of the analysis of commuting patterns show that while the number of people that commute to Oslo municipality has increased, the share of the population in the Greater Oslo Region that commutes to Oslo has decreased by 1.3 per cent. Commuting to the regional cities has also increased in number of commuters for every city except Sandvika, and the share has increased for every city except Sandvika and Ås. In total, the share of the population commuting to the regional cities combined has increased by around 0.5 per cent. This does indicate that the urban structure of the Greater Oslo Region has become slightly more functionally polycentric between 2001 and 2015. The regional cities seem to have gained a larger share of commuters compared to Oslo when looked at combined. Thus, the regional cities can be said to have become slightly more important as functional centres in the region while Oslo has become slightly less important.

However, as mentioned, not every regional city has become more important, and Jessheim has gained a considerably bigger share of commuters than the other regional cities and is largely responsible for the total change of 0.5 per cent. The average change for all the regional cities reflects this, as the average change is just 0.078 per cent, a significantly smaller gain compared to the gain for all the regional cities in total. While the regional cities have clearly increased their share in total and on average compared to Oslo, exactly how much the regional cities have gained and how much of a change for the urban structure in terms of functional polycentricity this reflects is a more complicated question.

Because Jessheim alone has had such a large increase in share of commuters compared to the other regional cities, the average change reflects the actual change for the regional cities
combined more accurately. Lillestrøm, Ski and Asker, the three other regional cities with increased share of commuters, have had an increase between 0.05 per cent to around 0.1 per cent, meaning the majority of the increases are around 0.1, and not 0.5 per cent. Even though the increases for the regional cities aren't that large, Oslo's large decrease contributes to a bigger difference in change between Oslo and the regional cities, the difference being 1.4 percentage points.

The same pattern of decentralisation where the dominant centre is gained on by the other centres is also evident within Oslo municipality as well, on an intra-urban scale. Oslo city centre, the dominant centre within Oslo, has had the largest decrease, and the majority of the other employment centres have had increases. Oslo city centre is not only the dominant centre within Oslo municipality, but also in the region as a whole with over 7 per cent of the population commuting to it in 2001, well over the total for all the regional cities combined. The relatively large decrease (-1.102 per cent) of the share of population commuting to Oslo city centre seems to be the main explanation for why the share of population commuting to Oslo municipality has decreased by 1.327 per cent.

The indication that the regional cities have strengthened their position as functional centres in the Greater Oslo Region compared to Oslo is reinforced by the analysis of which municipalities people commute from. Every regional city with the exception of Sandvika have had increases in more municipalities than there are municipalities with decreases in share of population that commute to the regional city from 2001 to 2015. Primarily, commuting has increased from the municipalities surrounding each regional city, but at the same there is a general tendency of small increases in municipalities further away as well. This indicates that the regional cities have increased their reach as functional centres in the region, with the exception of Sandvika. Commuting from the same municipality the regional city is located in has decreased in every regional city apart from Jessheim and Asker. At the same time, commuting to Oslo municipality has decreased in 11 municipalities, while there is no visible increase in any municipality. This also confirms the finding of Oslo having become slightly less dominant as a functional centre from 2001 to 2015.

Altogether, the findings from the analysis of the commuting patterns do seem to indicate that the Greater Oslo Region has become slightly more functionally polycentric. While commuting to the regional cities hasn't increased much, with the exception of Jessheim, 6 This begs the question of whether the regional cities strengthening their position as functional centres has increased overall commuting distance in the region.
and since there is decreased commuting to Sandvika and Ås, it cannot be said that the regional cities have greatly strengthened their position. The effect is, however, reinforced by the fact that commuting to Oslo and especially Oslo city centre, has decreased at a much greater amount, relative to the regional cities. In essence, this means that the number of new jobs in Oslo has increased but has not increased relative to population development in the Greater Oslo Region. In the majority of the regional cities the number of jobs has also increased, and increased relative to population development. How significant these changes are is hard to say without analysing a dataset for a longer period of time to find a benchmark rate of change to compare with. It also might be that the 14-year period studied is too short to notice any significant change in urban structure as these are slow to manifest. With that said, the findings do support the claim that the regional cities have become slightly more important parts of the commuting network that makes up the Greater Oslo Region, while Oslo has become slightly less important.
5 Conclusion

5.1 Has the Greater Oslo Region developed towards a polycentric structure between 2001 and 2015?

This thesis has explored the development of the urban structure in the Greater Oslo Region between 2001 and 2015 with the aim of discovering if the region has developed towards a polycentric structure. A polycentric urban region (PUR) is a region with several centres of similar size. It is the opposite of a monocentric region with one dominating centre. In several strategic plans for the Greater Oslo Region, Norway, and in Europe, polycentric development is a spatial development guideline. The Regional Plan for Land Use and Transport in Oslo and Akershus (Plansamarbeidet 2015), the strategic platform for Oslo municipality and Akershus county, has the aim of making the region more sustainable and competitive. One of the ways they want to do this by is making sure the urban growth pattern is concentrated and based on polycentric development where regional centres gain size and functional importance in the region. The plan outlines several prioritised growth areas, among these, six regional cities: Sandvika, Asker, Lillestrøm, Jessheim, Ski and Ås. These regional cities are chosen to study the polycentric development in the Greater Oslo Region.

Polycentricity can be interpreted in a morphological and functional context. The morphological context refers to a PUR as a region with several centres of similar size, for example population size. Much of the literature on polycentricity has interpreted it in this context. In the functional context, the centres have to be of similar importance or functional size. This is determined by how connected the centres are to the rest of the region through various flows, like flows of people. This thesis has explored the polycentric development of the Greater Oslo Region in the morphological and functional context. For the morphological context, population data has been analysed to see if the regional cities' population has grown faster compared to the dominant centre in the region, Oslo. And for the functional context, commuting data has been analysed to see if commuting to the regional cities has grown more than commuting to Oslo. One main research question and two sub research questions have guided the thesis.

*Has the population increased at a higher rate in the regional cities of Akershus in comparison to the city of Oslo between 2001-2015?*
Taken together, the population in the regional cities has increased at a fairly similar rate as the population in Oslo between 2001-2015. The total annual growth rate for the regional cities is 1.70 per cent, while for Oslo it is 1.74 per cent. Individually, Asker and Sandvika have grown at a considerably slower rate than Oslo, while Jessheim has grown at a considerably faster rate than Oslo. Lillestrøm has also grown faster than Oslo, Ås has only grown slightly faster, and Ski has grown slightly slower.

*Has commuting to the regional cities of Akershus increased in comparison to commuting to the city of Oslo between 2001-2015?*

Commuting to the regional cities has increased slightly in comparison to commuting to Oslo between 2001-2015. The per cent of the population in the Greater Oslo Region that commute to Oslo has decreased by 1.3 per cent, while the per cent has increased by around 0.5 per cent for the regional cities in total and 0.078 per cent for the regional cities on average. The share of the population commuting to Lillestrøm, Ski, and Asker has increased by between 0.05 to 0.1 per cent, and to Jessheim it has increased 0.4 per cent. To Sandvika the share has decreased by 0.2 per cent, and to Ås decreased by 0.05 per cent.

*Has the Greater Oslo Region developed towards a polycentric structure between 2001 and 2015?*

The results from the analysis of the population data show that the Greater Oslo Region has not become more morphologically polycentric from 2001 to 2015. Since Oslo and the regional cities in total have grown at a fairly similar rate there has not been much change to the morphological structure and the predominantly monocentric structure has been sustained. Although there are differences in the growth rates between the cities, overall, there are few indications that the regional cities have been catching up to Oslo during the period in regard to population size, since only two regional cities have noticeably higher annual growth rates.

The results from the analysis of the commuting patterns show that the Greater Oslo Region has become slightly more functionally polycentric. Since the share of the Greater Oslo Region population that commute to the regional cities in total has increased by 0.5 per cent and on average increased by 0.078 per cent, and at the same time the share of the population that commute to Oslo has decreased by 1.3 per cent. At the same time, since the share of population commuting to the regional cities from municipalities further away has slightly increased, the regional cities can be said to have slightly increased their reach, while Oslo's
reach has slightly decreased. Within Oslo municipality, the tendency is the same. Oslo city centre has had decrease in share of population that commute to it and thus become less important as an employment centre, and the majority of the other employment centres have increased their importance. Altogether, the results indicate that the regional cities have gained functional size compared to Oslo from 2001 to 2015.

Certainly, the Greater Oslo Region is still dominantly monocentric both morphologically and functionally. However, the results indicate that the urban structure of the region has remained largely unchanged morphologically but has become slightly more functionally polycentric on an inter-urban scale, since Oslo as the dominant centre has slightly lost importance as a functional centre and the regional cities as subcentres have slightly gained importance. And Oslo municipality has also become slightly more functionally polycentric on an intra-urban scale.

It is difficult to say with any certainty whether these results represent a long-term trend where the population continues to develop at a similar annual growth rate in regional cities as Oslo, while the regional cities continue to become more functionally important compared to Oslo by having a higher share of job growth, relative to the population development in the Greater Oslo Region, compared to Oslo. Does this represent a trend of decentralisation of economic activities in the region or is the small shift from monocentric to polycentric functional structure just temporary? If the reason for this increased functional polycentricity is the regional planning policies, then we can expect the increase to continue.

5.2 Further research

Further research into the state of polycentric development in the Greater Oslo Region is needed. One avenue to explore is the evolution of total distance travelled by commuters within the region over the past decades, with a differentiation between travel modes. Since the results from this study shows that the Greater Oslo Region has become slightly more functionally polycentric, the theoretical expectation is that the total distance travelled should have decreased slightly as well. If this has actually happened would be interesting to find out, especially since the reach of the regional cities also has increased slightly according to the results from this thesis, an indication that distance travelled in fact has increased. This would help shed light on whether polycentric development really reduces the total distance travelled.
Another avenue to explore is the reasons for the slightly increased functional polycentricity. Why has Oslo become less important as an employment centre relative to the regional cities? Is it mainly due to the Greater Oslo Region's specific planning policies with the aim of polycentric development, or are the reasons simply because rent for office and retail space is cheaper outside Oslo? This would help answer if the results of this thesis show a long-term trend.
References


