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**No longer monocentric, not yet polycentric.**

**On changes of spatial structure and mobility in the Munich Metropolitan Region**

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**Abstract**

The Munich Metropolitan region (MMR) features a radial transportation system as well as a high concentration of jobs and population in the core city of Munich. Morphologically speaking, it is hence a rather monocentric space. Concentration in one central large-scale urban region causes uneven spatial development, and thus a continuous increase in spatial disparities. This development is accompanied by a shortage of affordable housing in central locations and results in distinct consequences on daily mobility. Polycentricity might contribute to more balanced and more sustainable mobility, but requires better allocation of local urban amenities as well as public transport connections linking nodes tangentially. From a relational perspective, the MMR shows potential for developing polycentric features.

In recent years, structural change towards functional polycentricity has become part of the agenda in regional planning and development discussions. Municipalities, enterprises, and service providers aim at improving intra-regional cooperation to join resources. Supra-local cooperative efforts hence call for thorough analytical knowledge about location choices regarding employment and housing as well as transport networks, and how these three structural dimensions interact with each other over time.

This paper introduces a study that aims to understand this complex interplay and process of transformation within the MMR. The study combines a macro-perspective analysis of indicators of socioeconomic structures and spatial accessibility with the micro level of individuals who face decisions where to live, where to work and how to optimize their daily mobility patterns. Households that have moved or changed jobs within the last three years were asked to reveal their location preferences in a web based survey. The respondents geo-referenced their present and former places of work and residence, assessed qualities of

alternative locations, and revealed tradeoff motifs, income, as well as housing costs. The respondents faced three situations: before the move or job change, during the search for alternative housing, and after the move or job change. A key hypothesis assumes that households aim to optimize distance and transportation costs between residence and work place. This may lead to growth at highly connected urban nodes with good public transport access. However, in case of high housing costs, dispersion into less integrated parts with relatively low rents might be the outcome. The study's results are intended to provide a thorough base for strategic debates on promoting integrated nodes of urban development and provision of public transport infrastructure.

**Keywords:** Munich Metropolitan Region, housing markets, labor markets, commuting, transport systems

## 1. Introduction

The emergence of polycentric metropolitan regions is strongly interlinked with a new division of labor and an economic change towards knowledge intensive activities (Hall 2009; Sokol, van Egeraat and Williams 2008; Lüthi, Thierstein and Goebel 2010a). This economic shift results in a re-organization of value creation and innovation processes and comes along with an up-scaling of spatial interdependencies. However, emerging polycentricity faces a rather slow and persistent spatial structure drawing back to monocentric patterns. Monocentricity in this sense means a single center that serves a clearly defined area delineated by non-overlapping market areas. This might be referred to as a Christallerian like organization of settlements.

The Munich Metropolitan Region (MMR) as an example of monocentricity is experiencing increasing stress due its above-average growth rate. Negative effects include a competition-driven housing market and a transport system that is operating at capacity limit. The limited availability of housing results in tradeoff processes, where housing with desired attributes is either very expensive or not available. Households that cannot or do not want to afford higher prices end up choosing less accessible locations. These processes also affect mobility behavior, enforcing longer commuting distances and car dependency.

In order to decrease the pressure on the City of Munich, polycentric tendencies need to be strengthened. This requires the identification of main drivers for spatial development, possibly leading to the emergence of polycentric city regions. Better spatial and transport planning is crucial for increasing the attractiveness of sub-centers compared to dominant core cities.

## 2. From monocentric to polycentric city regions

Metropolitan regions in western countries are undergoing structural changes in which the emergence of polycentricity is observable. The outcome of such change is the loss of relative importance of core cities or traditional economic centers and the emergence of other centers that yield an importance which is not necessarily a function of their population or employment size but rather a result of specific knowledge resources or spatial qualities (Kloosterman and Musterd, 2001; Scott et al., 2001; Phelps and Ozawa, 2003). This section outlines firstly a basic understanding of emerging polycentric spatial structures. Secondly, it aims to link this development process to the main drivers: private households and companies and both their decision making process in choosing locations.

### 2.1 Emerging polycentric structures

In order to assess an emerging polycentricity in city regions and metropolitan regions, we will draw a reference to monocentric city models. This provides a basic understanding of an urban system and its changes over time. Among others, Christaller has introduced an early definition of interdependent cities and their surrounding hinterland. This Central Place Model defines a monocentric urban system with clearly defined boundaries of non-overlapping market areas (Christaller 1933). The basic feature of the Christaller system is, that “the higher the level of a center, the greater the number of sets of goods supplied from it, the greater its population; the greater the size of its characteristic market area; and (because of this) the lower the

frequency of such centers and the wider their spacing.” (Parr 2013: 7). Thus, the urban system is characterized by the spatial aggregation of commodities and services in certain locations, the spatial range of these goods and services and the hierarchical level regarding the centrality of these goods and services (Scott 2012: 16). However, this spatial organization with its strong reference to a hierarchical urban system fails to explain spatial development processes adequately. Globalization and the growing importance of knowledge intensive businesses call for relational and more network based paradigms to study urban systems (Taylor, Hoyler and Verbruggen 2010; Meijers 2007; Camagni 1993).

In order to better understand contemporary urban systems, Pred (1977) refers to the growing importance of interdependency and complementarity between cities and city regions. Interdependency between city regions results from value creation linkages or decision making processes in multi branch firms (Pred 1977: 19). Complementarity represents a “situation in which different cities fulfil different and mutually beneficial roles” (Meijers 2007: 248). According to this reading of city regions as interdepending and complementing spaces, a momentum of specialization comes into play. The exploitation of economies of scale fosters growth in specialized location which in turn results in a polycentric structure. This development process might undermine the traditional monocentric system with nested markets areas (Camagni 1993: 76). Maillat (1998) even identifies the inherent potential for fundamental changes within an urban system, since these specialized locations might realize strong growth.

The emergence of polycentric city regions is closely linked to a “new division of labor” and the rise of a global knowledge economy (Sokol 2008). Flows, such as movement of people, transfer of capital or exchange of information are a key element of the society and induce a “new spatial logic” in which locations exert a meaning as nodes in networks (Castells 1989). According to Hall and Pain (2006), the development processes towards polycentric urban structures include either a “long process of very extended decentralization from large central cities to adjacent smaller ones” (Hall and Pain 2006: 3) or “outward diffusion from major cities to smaller cities within their spheres of influence” (Hall and Pain 2006: 12). In both cases the relative importance of the traditional center decreases and other locations participate with their specific functions – be it transportation infrastructure such as airports, or specialized knowledge resources.

Summing up, polycentric city regions have multiple centers that jointly service a market area in a complementary spatial division of labor. Contrastingly, monocentric city regions have a clear distinction between the urban core and the surrounding hinterland and, thus, non-overlapping catchment areas.

## **2.2 Individual choices and polycentric city regions**

A key driver of development within polycentric city regions is given by individual households and their decision making process in terms of where to live, where to work and underlying mobility. Storper (2013: 4) suggests that “City regions are the principal scale at which people experience lived reality.” Mobility and commuting in particular play crucial roles in this development process. According to Parr (2013: 10), commuting is a “lubricant for both labor-market flexibility and residential adjustment.” In this regard, the mobility of commuters

enables “changes in the location of the workplace, with the location of residence remaining unaffected, as well as changes in the location of residence with the location of the workplace unaffected.” (Parr 2013: 6) This idea points to the basic findings of urban economics and the relevance of agglomeration advantages. As suggested by Glaeser (2011: 6): “Cities are the absence of physical space between people and companies. They are proximity, density, closeness.” Nevertheless, closeness and density are not necessarily limited to a single city center. However, there is no clear definition of closeness (Gertler 2003). Moreover, there seems to be a coexistence of multiple economic centers and processes that are interlinked and hence form a polycentric urban space (Burger, Meijers and van Oort 2014). Therefore, we have to consider polycentric regions as an intersection of multiple economic processes and the preferences of households.

From an employee’s perspective, city regions offer access to different job opportunities, residential locations, and transportation supply. People choose their place of residence according to a number of factors. These include size of the dwelling, distance to their work place, their potential neighborhood, accessibility, and quality of schools or services that are available in close proximity. Altogether, a large number of amenities needs to be taken into account. Once a decision is made for a certain apartment or house, it always comes along with a number of advantages or disadvantages. A dwelling in a suburb might provide more space at a lower price, but in turn the distance to work or other destinations is much longer. People choose the bundle of factors that represents the best choice for their situation, regardless that some single factors might have a negative outcome (Storper 2013: 80-81; Storper and Manville 2006). In other words, people tradeoff certain factors such as housing size for good accessibility.

From the perspective of employers or firms, the spatial shifts in city regions and an emerging polycentric structure offer potential business locations other than the most central places in core cities. Employers also have to balance the advantages and disadvantages of central locations and less central locations (Kloosterman and Musterd 2001: 625). Higher costs at central locations might have the advantage of higher accessibility and lower transportation costs for the work force.

Individual choices, economic composition, and spatial structure given by the distribution of centers and the provision of transport show a broad spectrum of intertwining development processes. The emergence of polycentric city regions seems to be involved in such an interplay. Regarding individual choices in this context suggests considering polycentric urban spaces in terms of providing a wider range of different alternatives of choices. Consequently, fostering the competitive advantage of a metropolitan region goes hand in hand with a polycentric spatial development.

### **3. The Munich Metropolitan Region**

#### **3.1 Structural Characteristics**

The Munich Metropolitan Region (MMR) is situated in the south of Germany, occupying close to 40 % of the area of the Free State of Bavaria (see Figure 1). At the same time, it is home to

almost 6 million of Bavaria's over 12 million inhabitants. Due to its manifold labor market, the region attracts more and more people each year, contributing to population growth and economic prosperity. The low unemployment rate of only about 3.5 % is a further indicator for excellent job opportunities in different branches (IKM 2012).

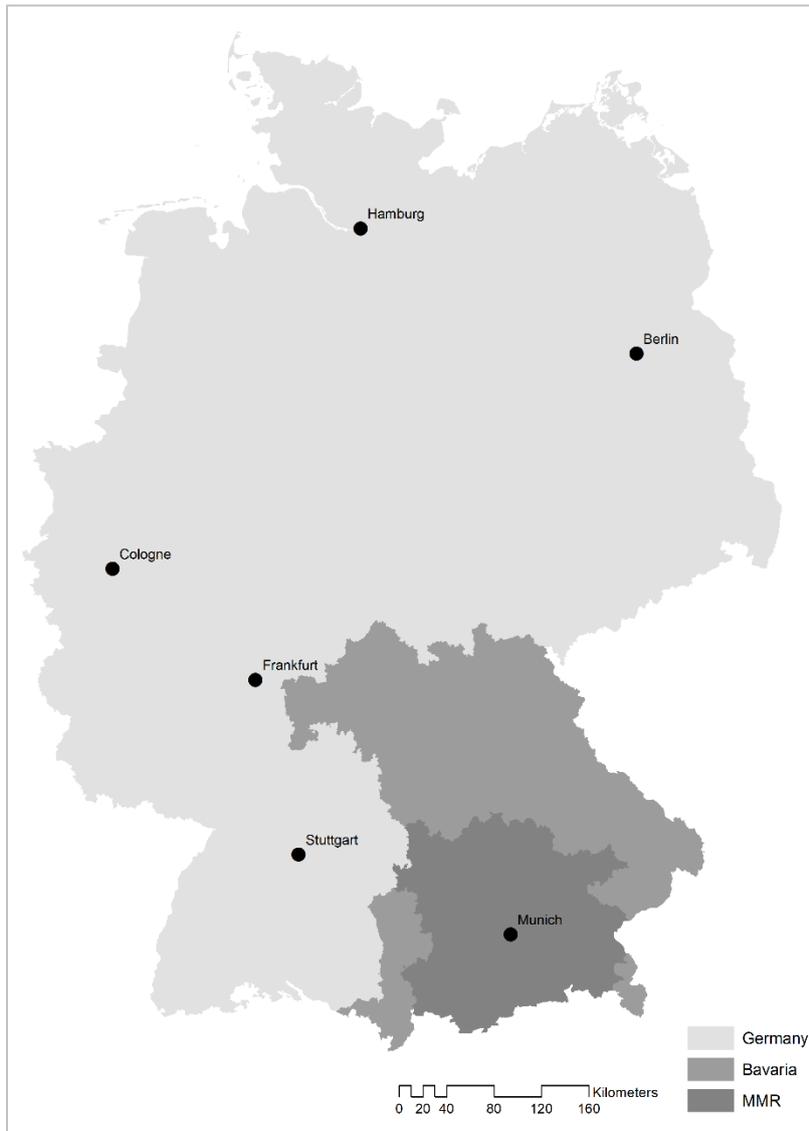


Figure 1: Location of the MMR within Germany and Bavaria

In the center of the area lies the City of Munich, eponym of the entire metropolitan region. Currently, more than 1.4 million people live in Germany's third largest city. Other main cities within the MMR include Augsburg, Ingolstadt, Landshut, Rosenheim, and Kaufbeuren. However, none of them compete against Munich's outstanding role. The City of Munich's special position within the region also reflects in the typology of the transport system. Railways and motorways form a radial system, merging in the City of Munich (see Figure 2).

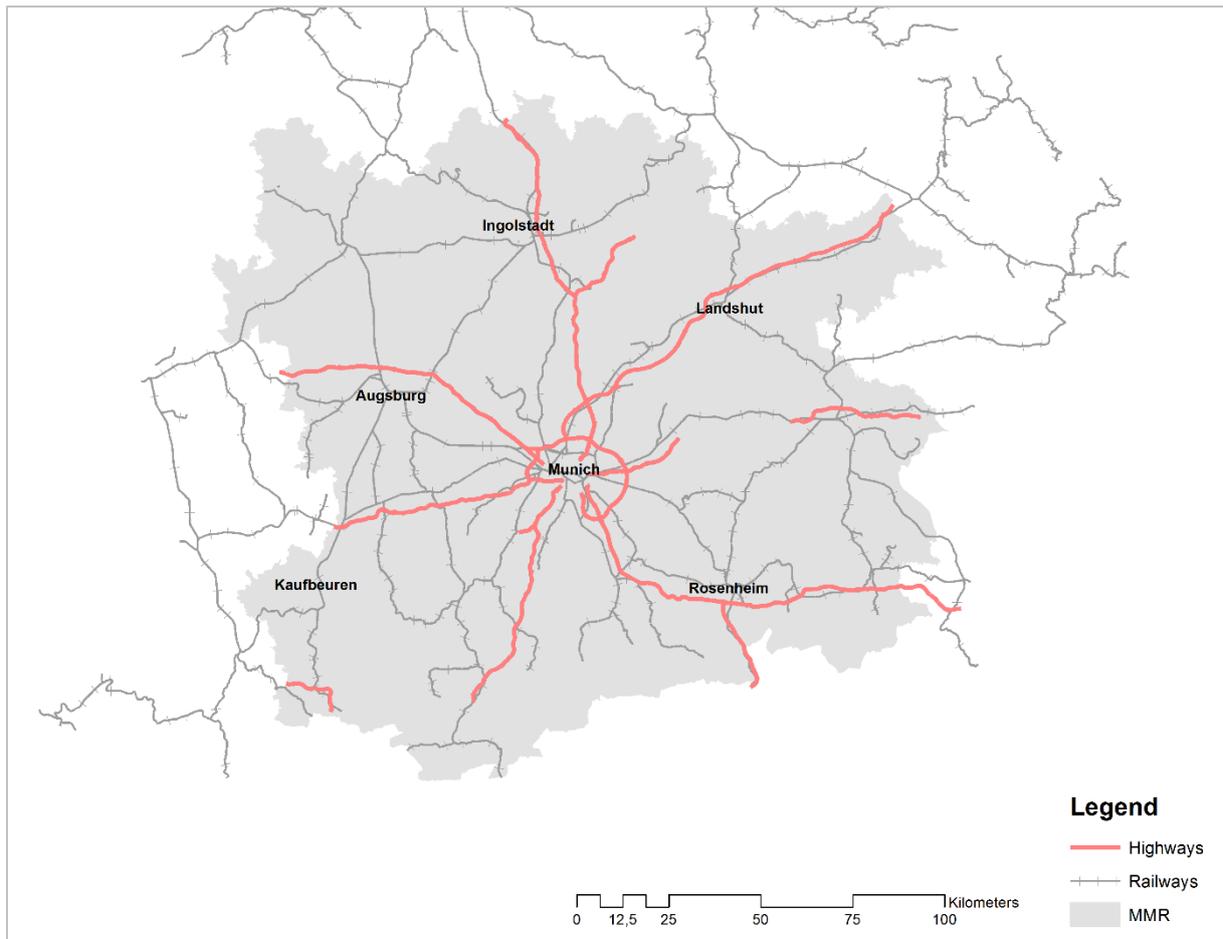


Figure 2: Transport infrastructure in the MMR

Also the majority of jobs is located in the core of the region. The following gravity-based analysis of public transport (PuT) accessibility to workplaces emphasizes the weight of the MMR's center. It combines the distribution of jobs in the area with the quality of the municipalities' PuT services. Workplaces within the considered municipality itself receive the highest weight. Other workplaces are assigned a lower weight depending on how distant they are. The weight is determined by a negative exponential function using PuT travel time as the independent variable. Very remote workplaces beyond a certain threshold are not taken into account at all. The region's employment hubs stand out in the resulting map. Due to a high number of jobs in the City of Munich and fast rail bound PuT connections, most of Munich's surroundings are colored in dark green, indicating a very good accessibility to workplaces. Also other communities along the main railways count among the most accessible locations. Potential for functional polycentricity shows when considering the effects of other central places in the region, like Augsburg, Ingolstadt, Rosenheim, and Landshut.

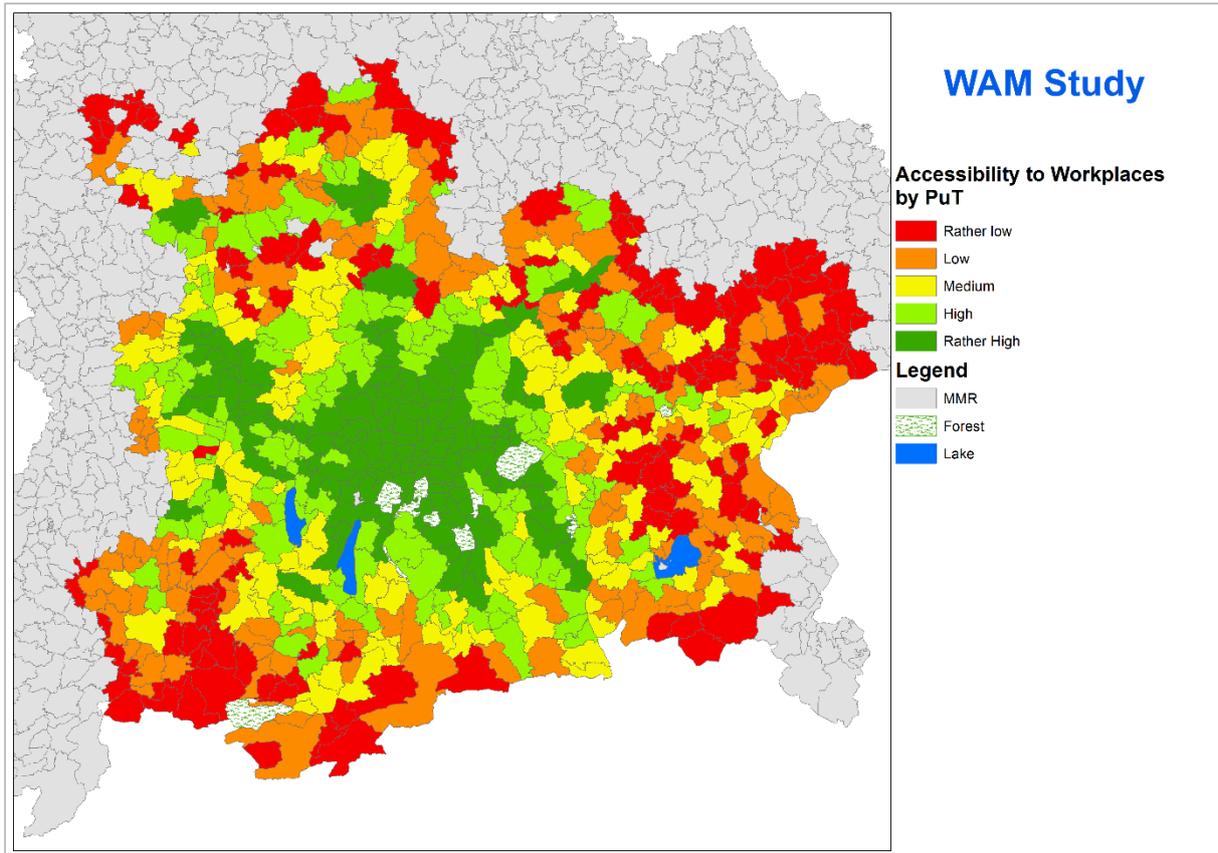


Figure 3: Gravity-based PuT accessibility to workplaces for MMR communities

The economic structure of the MMR is based on a strong high-tech sector combined with advanced producer services. These pillars of the knowledge intensive economy form a strong functional interrelation that results in a distinct spatial pattern of interdependent locations. Bentlage, Thierstein and Lüthi (2015, forthcoming) have shown that the city of Munich functions as a primary center with a strong concentration of advanced producer services. These firms provide consultancy in law, financing or design tasks and have a high importance for rather specialized production sites such as the automotive industry in the region of Ingolstadt or Deggendorf. Based on the case of Ingolstadt and the spatial reach of corporate knowledge networks in the mobility sector, the MMR appears as the most important reference space. While asking for the location of their partners in innovation projects, firms in the region of Ingolstadt indicate that nearly 70 % of all cooperation takes place within the MMR. The major part of these network linkages directs to the city of Munich (Thierstein et al. 2011). Another indicator for a spatial division of labor and an emerging polycentric structure is observable at the airport of Munich. This location provides global accessibility and attracts firms that operate within an international or global sphere (Lüthi, Thierstein and Goebel 2010a). These findings show that the MMR has a strong monocentric structure with a high degree of concentration in the city of Munich itself. Nevertheless, we observe an indication of strong interdependency between the city of Munich and the surrounding regions.

### 3.2 Recent Developments

As opposed to other parts of Germany, both population and number of workplaces are increasing within the MMR. This growth is not distributed homogeneously throughout the

region, but focuses on the most central places. This is especially true for the City of Munich and its surrounding municipalities. The largest future growth is also expected in the core of the region (Landeshauptstadt München 2012). In order to gain a better understanding of population and workplace development patterns, recent statistical data was investigated. Data from the Bavarian Agency for Statistics and Data Processing is available up to the year 2013. Due to a population census having been conducted in 2011, this year was chosen as the reference year.

The following map represents an overlay of accessibility and population development within the considered time frame. For the sake of simplicity, only two categories were used for evaluating accessibility. Municipalities were either attributed a high or a low accessibility, based on travel time to the closest main center. Main centers include Munich, Freising, Kaufbeuren, Augsburg, Ingolstadt, Landshut, Rosenheim as well as Garmisch-Partenkirchen. If any of these cities can be reached within less than 30 minutes by both PuT and private transport (PrT), the respective municipality was categorized as highly accessible. This applies to all areas colored pink or purple in Figure 4. As can be seen from the blue and gray areas, many communities located at larger distances to railways were assigned a low accessibility due to comparatively bad PuT connections.

Based on the population data provided, the proportional population growth was calculated for each community and compared to the average population growth in the entire region. Purple areas represent highly accessible parishes, where above average population growth has taken place between 2011 and 2013. Blue areas have experienced a similar increase in population while being less accessible. The opposite is true for pink areas, where population growth was lower despite a high accessibility. No or only moderate population growth has mainly taken place in less accessible municipalities colored in gray.

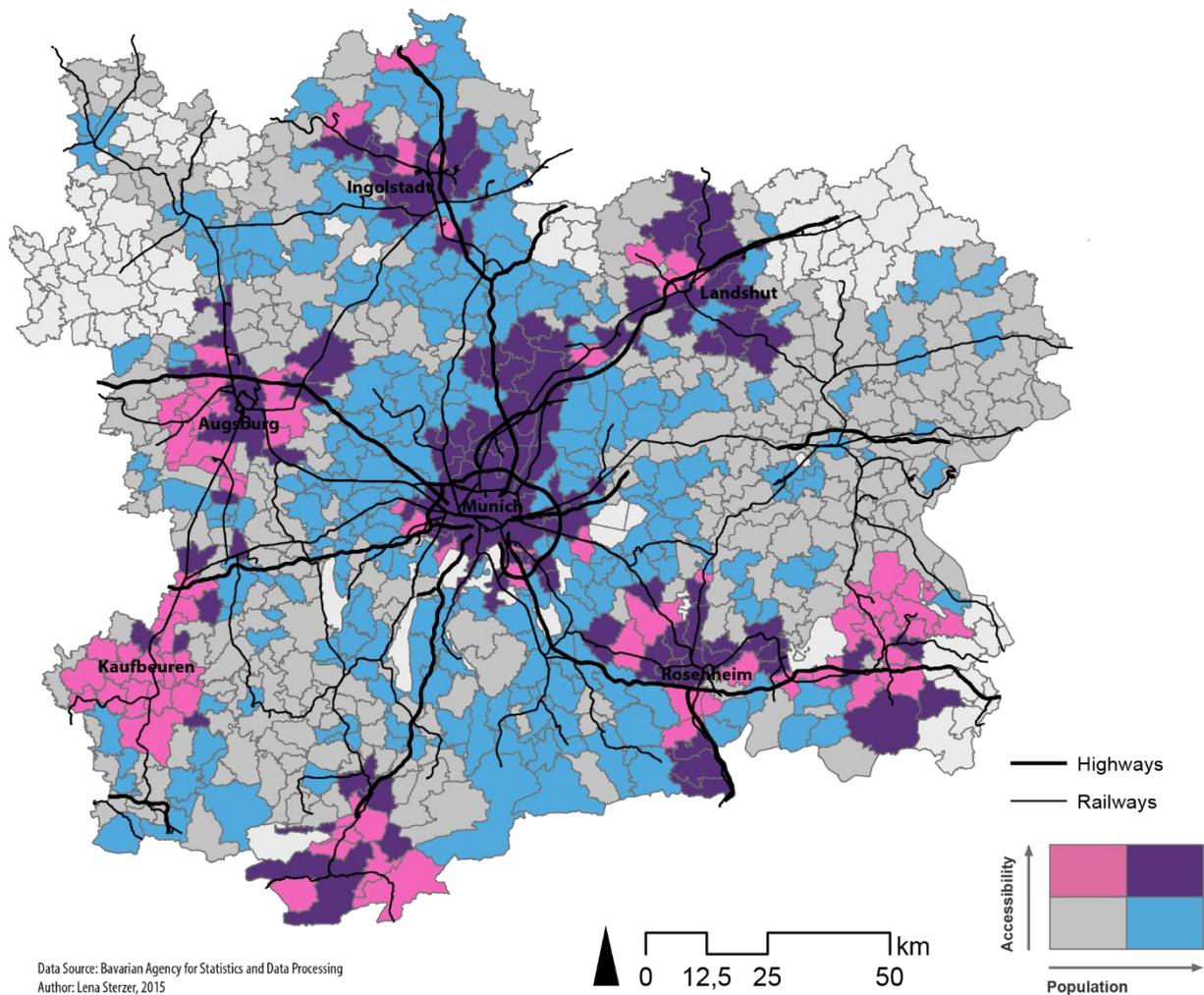


Figure 4: Population development versus accessibility 2011-2013

As the blue and purple areas indicate, population growth has mainly taken place in the core of the region. The city of Munich seems to be a major attractor, but also other centers like the airport region, Ingolstadt or Landshut have experienced an influx of population. Population has increased in transport nodes, but also in between major axes connecting the main centers, possibly indicating a spillover effect due to higher prices in the most central places. Future prognoses by the Bavarian State Agency for Statistics and Data Processing predict a less intense growth for coming years compared to the past time period. However, population growth will be even more focused in the core of the metropolitan region, as opposed to shrinking tendencies in fringe areas.

Workplace development is spatially differentiated within the MMR (Büttner et al 2014: 12) and thus less homogeneous than population development. Single communities with above average workplace development immediately border communities with below average development. However, stronger workplace development in the surroundings of all main centers is one pattern that can be observed. Also, communities with only slight growth or even a declining number of workplaces tend to be located in more peripheral parts of the MMR.

### **3.3 Emerging Challenges**

Obviously, the MMR is a rather monocentric metropolitan region. The City of Munich and its immediate surroundings emerge as the main center with the most attractive labor market and highest accessibility. Consequences of this dominant position are economic prosperity on the one hand, but also serious challenges on the other hand. A high housing demand in the City of Munich and its suburbs has put severe pressure on the housing market and has caused enormous price increases. Since businesses based in the region depend on skilled workers who in turn require adequate housing, they are also affected by the current situation. Many people searching for housing end up with tradeoffs, where certain requirements cannot be met. They either cannot afford to live where they would like to or are facing too much competition. For the City of Munich, this has been proven in a recent study at the Chair for Urban Development (Thierstein et al 2013). Accessibility is one of the criteria that can often not be met, causing a displacement of certain groups of people to more peripheral locations. This results in increasing commuting distances, but also has an effect on trip length to other activities like the fulfillment of basic needs, leisure or shopping (Büttner et al 2014: 13). Many communities not only lack utilities, but also PuT services, forcing inhabitants to rely on PrT. Due to extensive commuting activities, the transport system in the greater Munich area is already operating at capacity limit, making a comprehensive strategy for mobility planning inevitable.

It is the responsibility of regional stakeholders to cooperate in order to tackle these problems. Other main cities in the region need to be strengthened for the generation of a more polycentric spatial structure that might take some pressure away from Munich. In order to find an adequate spatial planning strategy, it is necessary to understand ongoing trends and what is causing them. The study introduced in the following chapter is supposed to shed light onto the interactions between housing, working, and mobility. It investigates where people live, where they work, how they move, and aims to identify the underlying rationale for different groups of people.

## **4. WAM-Study**

### **4.1 Hypotheses**

The extensive preparatory research and identification of current trends helped to gain the basis for understanding ongoing dynamics within the MMR. These dynamics seem to stem from a reorganization of labor, demand-oriented housing markets, and a change in individual preferences with respect to housing, working, and mobility. Based on this existing knowledge, the research team developed several hypotheses regarding the main motives for households' spatial decisions.

In times of increasing specialization, joining forces in collaborative ventures become more important. Competition for skilled, well qualified employees is growing with an increasing knowledge intensity of innovations. A well accessible location is crucial regarding opportunities for cooperation and exchange beyond a local context, and makes collaboration in knowledge intensive branches easier. Thus, a high accessibility might be a prerequisite for

a company's economic prosperity. Recent trends support this assumption, confirming that workplace growth within the MMR occurs in the most accessible locations like Munich, Ingolstadt, and the airport region (Lüthi, Thierstein and Goebel 2010b).

The concentration of value creation comes along with a concentration of the labor force. Due to the importance of convenient commutes, employees are expected to optimize their residential location with respect to daily distances and time travelled, as well as transportation costs. In case of double income households, a compromise has to be found in order to ensure the convenience of trips to all work locations. The shortest overall trip lengths will most likely be achieved in a central location (Hu 2014) Employees are furthermore expected to be flexible, mobile, and willing to travel. High accessibility enables flexibility, also in case of part-time or temporary employment, and opens up a broad range of career opportunities. Job changes can be done quickly, without necessarily changing the residential location (Rosenthal and Strange 2003). Not work-related urban qualities are increasingly valued as well, partly due to changes in lifestyle. These include shopping and service opportunities or availability of leisure and cultural activities. The sum of all these factors regarding housing, working, and mobility favor central location choices.

Being the most accessible location within the MMR, the sole focus has been on the city of Munich for a long time. The high demand due to this monocentricity caused a shortage of affordable housing and capacity overload of the transport system. This tradeoff between a central housing location and affordable living conditions results in a complex decision making process. Therefore other well integrated locations might become the new centers of attraction. Sub-centers offer bigger dwelling sizes at a lower price while simultaneously providing for the main urban qualities desired by individuals.

Spatial dynamics will be accompanied by changes in mobility behavior. Concentration in central locations results in shorter distances between residential location, workplace, and other activities while enabling efficient trip chains at the same time. On a bigger scale, strong interactions with other centers strengthen the need for better connections between different nodes. Together with high population densities, this precondition enables the establishment of an effective PuT system that might serve radial as well as tangential demand. New mobility options urge preferences regarding the means of travel to shift from PrT to PuT. The aim is to keep mobility costs low and avoid time losses being stuck in traffic. As a consequence, households preferably improve their PuT access by trying to find an affordable housing location close to a PuT station.

The following table summarizes some key hypothetical causes and effects that are thought to favor the emergence of polycentric structures.

Table 1: Causes and effects favoring polycentric spatial structures

CAUSE	EFFECT
✦ Working together in knowledge-intensive branches	Regional accessibility of chosen location: BAD → GOOD
✦ Importance of short distances to different opportunities, working in several locations	Residential location choice: PERIPHERY → CENTER
✦ High prices for adequate housing, need for more space	Residential location choice: MAIN CENTER → SUB-CENTER
✦ Improved infrastructure for public transport or unsatisfactory conditions for car traffic	Access to PuT: BAD → GOOD
✦ Change in personal preferences with respect to transport modes	Mode choice: PrT → PuT

## 4.2 Methodological Approach

In order to understand ongoing spatial developments on the macroscopic scale of the entire region, knowledge is needed about decisions that are made on the microscopic scale of single households. Of special interest for this study are households' location choices as well as the underlying motives. For that purpose, a survey was designed that addresses households that have changed their job or housing location within the last three years. The questionnaire consists of three main parts:

The first part includes questions on the current situation regarding housing, working, and mobility. In order to gain precise information about the current place of residence, people had to geo-reference their home address on an interactive map. In order to be able to assess the geographical location of the housing from a rather objective perspective, the precise location has to be known. Other important traits of the housing, like size, type and costs were surveyed additionally. Personal, subjective preferences were collected as well in order to be able to define those housing criteria that are most important to households. The survey continued with asking employees to geo-reference their workplace location. In addition, some background information on occupation, branch, contract type, and preferences regarding the surroundings of the workplace was collected. Questions on current mobility behavior, referring to monthly costs, car ownership, and availability of a PuT ticket concluded the first section. Important information was gained about overall mobility behavior, with households revealing their mode choice for different activities. These include not just the way to work, but also leisure and shopping activities as well as trips to services.

The second part was designed for households that changed their residential location and served to gather data about the search process. Households gave detailed information on alternative housing locations, their location and other qualities.

Finally, the third part, served to gather information about the households' situation before the move or job change. It was set up in analogy to part one in order to make the two points in time comparable.

### 4.3 Preliminary Results

The web-based survey was conducted from December 2014 to April 2015. Altogether 7.308 data sets were collected within this time period. The majority of replies came from the greater Munich area. Mode choice behavior of surveyed commuters aggregated on municipality level is illustrated in the following figure.

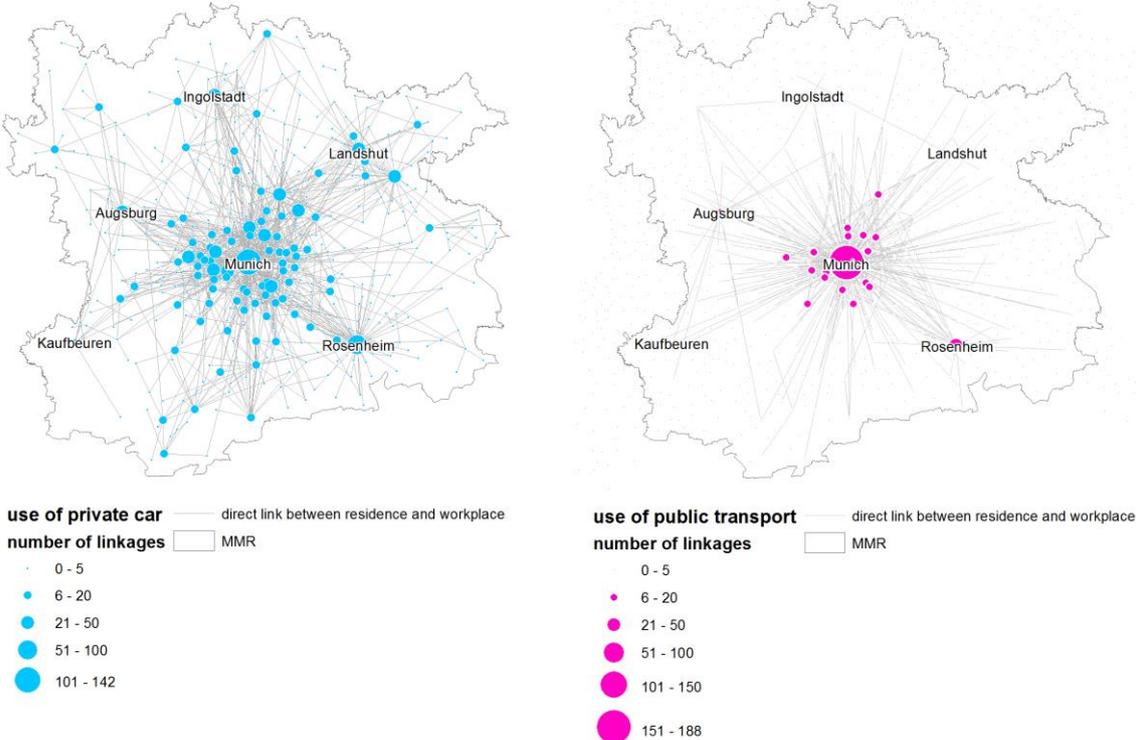


Figure 5: Comparison of PuT and PrT commutes. Data Source: WAM survey

The illustration of commutes by PuT emphasizes the radial orientation of PuT infrastructure towards the City of Munich and indicates a lack of tangential connections. While the majority of lines originates in the City of Munich, only single tangential commuter relations can be observed. Due to an unsatisfactory PuT/PrT travel time relation, tangential trips are rather car dependent, making PrT the usual choice of mode. PrT relations are more disperse, linking several smaller communities also tangentially. Strong relations can mainly be observed between the City of Munich and some of its surrounding communities, namely Garching and Freising.

## 5. Conclusion and Outlook

Analysis of statistical data and first results of the survey both undermine that the MMR is rather monocentric. While the City of Munich as the main center of attraction is facing problems like shortage in affordable housing and an overloaded transport system, other cities within the region have the potential to promote a more polycentric spatial structure. This potential can be realized given adequate provision of amenities and better PuT connections.

Further analysis of the survey data is expected to reveal households' preferences with respect to locational qualities. These findings will not only yield explanations for the current development, but also indicate qualities that households expect from their residential or workplace location. This newly gained knowledge will help to develop proper planning strategies. Regional stakeholders can apply it in the fields of housing, working, and mobility. Politicians, authorities, providers and operators of transport infrastructure, private companies, commercial stakeholders, and financiers will need to cooperate in order to steer spatial development into a sustainable direction. Better planning of labor and housing supply both within the City of Munich and in the entire region is needed. Profiles of sub-centers need to be enhanced to make them more attractive as a living location. The provision of adequate, affordable housing is essential, especially as to prevent a lack of skilled labor. Also the needs and preferences of the local labor force need to be understood in order to recruit and retain qualified workers (Büttner et al 2014: 16). Additionally, accessibility throughout the MMR needs to be improved by establishing attractive PuT services both between and within different labor hubs and residential centers.

While the planning and realization lies in the hands of many different stakeholders, this research project aims to give them the basic knowledge needed and help them choose the right path for a sustainable development of the entire region.

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