Essays on Household Mobility and the Quality of Life in Germany

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Für meine Eltern

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Introduction

Once aware of its powerful impacts, the mobility of human beings becomes a fascinating subject to analyze. From the personal point of view, a change of residence or a journey to unknown regions is able to re-adjust one's view on things and it can even bring about major changes in life. From the bird's eye perspective, the aggregated effects of mobility can sometimes be plainly stunning. The deep and far reaching consequences of the Migration Period between the years 300 to 700 AD shaped the landscape of Europe (and other parts of the world) as we know it by now. The rapid and continued growth of a city like Dhaka, with its population skyrocketing from 2.2 million in 1975 to 13.5 million in 2007, will, beyond any doubt, leave the picture of Bangladesh permanently changed.[1] These are two admittedly extreme examples. However, they pointedly illustrate how human mobility constantly reshapes the reality we are living in. In Germany for instance, the share of people who live in cities with more than 100,000 inhabitants rose from 4.8% in 1871[2] to 30.9% in 2007.[3] The UN documents similar actual trends for the developing countries, with Africa and Asia having their shares of overall urban population more than doubled between 1950 and 2007.[4] It is therefore little wonder that research on human migration behavior

[1]The UN predicts the population of Dhaka to be 22 million in 2025. See UN (2008), p. 11.

[2]See Köllmann (1976).

[3]See Statistisches Bundesamt (2009), p. 40.

[4]See UN (2008), p. 5.

has a long history in many different scientific fields. Early works relevant to economics are for instance Ravenstein's (1885, 1889) "Laws of Migration", and, even earlier, von Thünen's (1826) "Der isolierte Staat". In spite of so much time passed since then, the issue remains a fascinating one. What is it that makes people move? What do particular places like Tokyo or Mexico City offer that tens of millions of people have decided to make their homes there?

The answers to these questions are, of course, manifold. However, there is a bottom line to any individual decision to move: At the very heart of it lies an expectation that the destination offers conditions that are, in some way or other, "better" than the status quo. That said, one must distinguish many different aspects of human migration behavior. Large and sudden migration flows are often triggered by drastic events like wars or famines. The steady flows from rural to urbanized areas observable in almost all countries in the world are obviously distinct examples of the same phenomenon. A marked distinction in the economics literature is the largely separate analysis of international and internal migration.[5] This division is somewhat startling as there is no obvious reason to assume a priori that the underlying motives of migration differ between both cases. More likely, it is the cost of migration – in the most general sense of the word – that distinguishes crossing national borders from moving within them from an individual point of view.

Speaking of gains and costs we enter the economic point of view, where the location decisions of households are usually seen as market outcomes. Von Thünen (1826) explained land rents and the location choice of rational individuals by the cost of agricultural production and the distance to the central market place. In the same spirit, the seminal works of Alonso (1964), Muth (1969), and Mills (1972) established the framework of the *monocentric city*. The individual location choice in models of this tradition is determined by trade offs between wages, housing costs, and the economic cost of commuting. Beyond

[5]See Cushing and Poot (2004).

these economic factors, the local *quality of life*, a notion subsuming the bundle of locally available amenities, was found to play a crucial role in the household's location choice.[6] In the tradition of Tiebout (1956), local attractiveness is largely owed to local governments that provide public services and impose taxes. Accordingly, he coined the view that migration is a form of people *voting with their feet*. Common to all these studies is the economic view that in migration equilibrium all relevant factors balance out, such that individual utility is equal across locations.

This dissertation consists of four self-contained empirical essays. Each of the essays tries to make a moderate contribution to the understanding of internal migration flows in Germany. Chapters 1 and 2 follow the tradition of Rosen (1979) and Roback (1982) and investigate the impact of local attributes on migration. Both chapters pursue the hedonic approach to measure such effects and have their focus on land prices. Chapters 3 and 4 both draw on the implications of the monocentric city model and concentrate on the relation between less densely populated regions and agglomerations. In this context, Chapter 3 examines the spatial effects of minimum wages. Chapter 4 employs a discrete choice model to analyze the household's location and commuting decisions.

Germans have a reputation to show great emotional attachment to their home regions and therefore lack mobility. Notwithstanding such conjectures, there is a sizeable degree of mobility observable in the country. Official statistics on domestic migration reveal that the total number of internal immigrants crossing the borders of German States (Länder) in 2005 was 1.07 million (*i. e.* 0.013 immigrants p. c.). Moves within the boundaries of the Länder even amounted to 2.58 million in 2005.[7] For comparison, the domestic in-migration over regional borders (NUTS-2 regions) in 2005 amounted to 0.33 million in

[6] As for instance in Graves (1976, 1979), Rosen (1979), or Roback (1982).

[7] Excluding moves within communities. See Statistisches Bundesamt (2007), p. 60, for the German figures.

Italy (*i. e.* 0.006 immigrants p. c.), 0.49 million in Spain (*i. e.* 0.011 immigrants p. c.), and 0.26 million in the Netherlands (*i. e.* 0.016 immigrants p. c.).[8] For the same year, the US Census Bureau (2006) reports a number of 1.16 million domestic migrants crossing State borders within the USA (*i. e.* 0.004 immigrants p. c.). Unfortunately, the size differences of these geographical entities are too large with respect to area and population to allow for direct comparisons. Nevertheless, the *per capita* figures suggest that domestic migration in Germany is not exceptionally small, at least not in the European context. Further evidence on household mobility in Germany is presented in Table 1. The total sum of internal migrants per 1,000 inhabitants in the German Länder in 2004 varies between 45.9 in Berlin and 80.4 in Schleswig-Holstein. The net-inflows per 1,000 inhabitants range from -6.1 in Sachsen-Anhalt to 3.9 in Schleswig-Holstein in 2004. The pronounced population shift from East to West Germany also becomes clear in Figure 1, where the net-inflows per 1,000 inhabitants are depicted at the county-level. Apart from the East – West migration, the map highlights particularly high inflows into the surrounding areas of urban centers like Berlin, Hamburg, or Munich.

Recalling the above stated motivation for migration, these shifts point at substantial differences in living conditions in Germany. Chapter 1 of this dissertation addresses the differences in the local quality of life across Germany. To do so, the hedonic approach pioneered by Rosen (1979) and Roback (1982) is applied to land-price and wage differences between the German counties. Even though this approach is well established in the USA, the concept has, to the best of my knowledge, so far not been applied to Germany. The investigation provides important insights into people's valuation of issues like crime, air quality, and local labor market conditions. It therefore provides regional as well as national policy makers with useful information about the actual perception and composition of quality of life. Starting point of the analysis is a simple spatial equilibrium model with

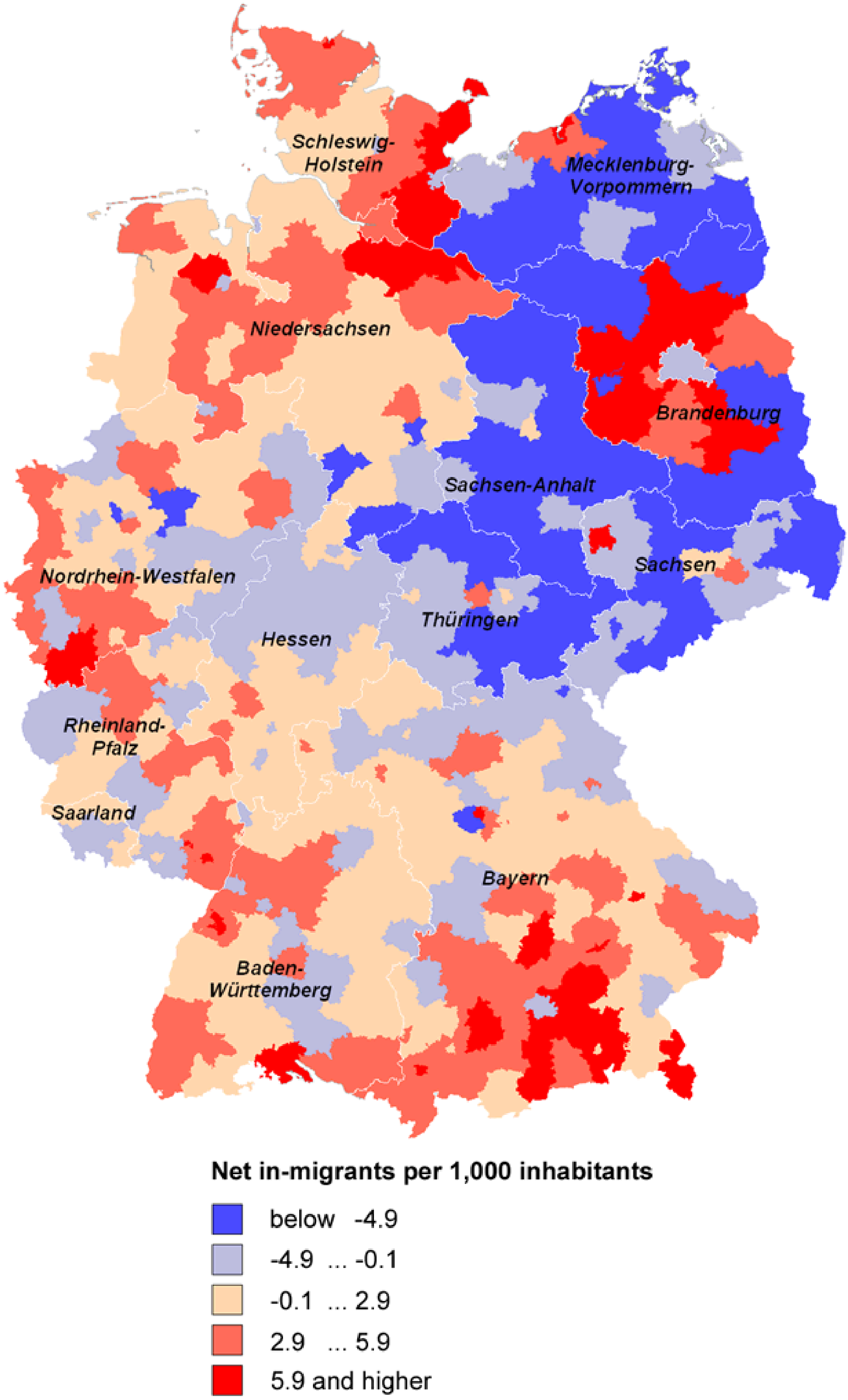
[8] All figures from the Eurostat database.

Table 1: Inner German Mobility

State	in-migration per 1,000 inhab.	out-migration per 1,000 inhab.	net in-migration[a] per 1,000 inhab.	total migration per 1,000 inhab.	job migration[b] per 1,000 inhab.	in-commuters per empl. in %	out-commuters per empl. in %	net in-commuters per 1,000 empl.
Schleswig-Holstein	47.3	43.4	3.9	80.4	-0.5	36.8	42.2	-95
Hamburg	48.8	47.3	3.9	66.3	31.9	36.3	14.1	259
Niedersachsen	46.7	44.3	-5.4	68.8	-15.9	30.5	33.7	-49
Bremen	45.9	42.2	1.7	68.1	5.8	42.5	18.4	294
Nordrhein-Westfalen	36.9	35.7	0.9	58.1	3.7	37.5	36.4	18
Hessen	49.9	47.9	0.9	65.7	6.7	45.8	42.4	59
Rheinland-Pfalz	42.8	40.2	2.0	68.7	1.4	43.0	48.5	-108
Baden-Württemberg	43.7	41.8	2.1	62.6	4.1	34.5	32.0	38
Bayern	45.3	43.2	2.1	68.2	4.7	42.6	41.7	15
Saarland	30.6	31.2	0.0	47.9	-4.4	42.7	37.6	82
Berlin	34.0	33.5	-2.7	45.9	7.4	40.5	35.4	79
Brandenburg	38.8	38.5	0.3	69.8	-14.6	34.0	43.6	-170
Mecklenburg-Vorpommern	38.3	43.3	-5.1	74.9	-22.3	31.2	37.2	-96
Sachsen	29.4	31.7	-2.3	52.5	-8.3	32.2	34.6	-36
Sachsen-Anhalt	28.9	35.7	-6.1	55.8	-21.0	31.6	38.0	-103
Thüringen	27.1	31.3	-4.4	52.7	-19.3	30.2	37.1	-111

[a]: Only inner-German migration flows. [b]: Net in-migration per 1,000 inhabitants aged 25 – 35 years, only inner-German migration flows. Proxy measure for existing disparities in job opportunities for young employees.
Data for 2004. Sources: National Statistical Office, Institute for Employment Research (IAB), Federal Bureau of Regional Planning (BBR).

Figure 1: Domestic Migration in Germany



Net in-migration at the county level in 2004. Source: BBR (2006) different locations, each of them providing distinct quantities of (dis-)amenities. As households and firms are assumed to be mobile between locations, spatial equilibrium requires that there exists no further arbitrage opportunity by moving. Thus, regional housing costs and wages will adjust according to the respective amenity levels at each location. To quantify these compensating differentials, the empirical analysis employs data from the "Perspektive Deutschland" study 2004, a large survey on a wide range of social and political issues among more than half a million Germans,[9] along with data on climate and official statistics. Hedonic regressions of wages and land prices are estimated to infer the marginal willingness to pay for regional attributes. The results show that regional differences in amenities do capitalize into land prices and explain a substantial part of the observed land-price variation across counties. With regard to wages, however, only little effects of amenities are found. According to the implied implicit prices of the amenities, quality-of-life differences are mainly driven by two sets of attributes. The first refers to geographical conditions, leisure facilities, and tourism-related amenities. The second set relates to local labor market conditions. Following Blomquist et al. (1988), a quality of life index for all German counties is derived, based on the highly significant land-market effects of amenities. The index indicates that in West Germany the southern regions rank highest, particularly those in the Munich area, as well as counties in Baden-Württemberg. The regions in the East show less pronounced differences in the quality of life, which to some extent reflects consistent labor market difficulties.

Chapter 2 is closely related to the first, as it also employs the hedonic approach to investigate the willingness to pay for regional attributes. However, it shifts the focus to public services provided at the community level and explicitly accounts for spill-over effects and spatial dependence. Unlike the counties analyzed in the first chapter, the German communities are not just administrative units. They represent the smallest entity in the German

[9]This study was initiated and conducted by McKinsey corporation. For an overview of the project see Fassbender and Kluge (2006).

federal structure and their elected governments dispose of substantial autonomy with respect to taxation and public spending. Objects of investigation are the 505 municipalities of the Free State of Saxony. Located in East Germany, this state has experienced a massive outflow of people after the reunification. A reliable measurement of the citizen's valuation of public services is therefore especially relevant at the community level, and it is almost vital for East German municipalities in particular. The empirical analysis uses data from a variety of sources. Due to a lack of reliable data on wages at the community level, the analysis is constrained to compensatory differentials on the market for real estate and does not consider the full general equilibrium model proposed by Roback (1982). Given the minor spatial extension of most communities, one must consider possible spill-over effects of local attributes. Residents of neighboring municipalities are likely to enjoy not only the amenities provided in their home community but also those in their surroundings. The estimation explicitly accounts for such spill-over effects by including spatial lags of the variables that capture public services and amenities. Moreover, possible spatial dependence in the error terms is taken into account to ensure correct statistical inference. The results show that most of the included public services do significantly capitalize into land prices, with the quality of public transport systems and the share of land dedicated to recreational purposes receiving the highest valuation by Saxony's citizens. The conjecture that local attributes also affect land prices in adjacent communities is confirmed as almost all spatially lagged indicators enter the estimation significantly. Again, the public transport system and recreational land in surrounding communities are found to have the highest hedonic prices. In general, substantial parts of the variation in land prices across communities can be explained by the employed set of variables.

Column 5 of Table 1 indicates that job migration accounts for large parts of total migration. Particularly interesting are the high net inflows into the cities of Hamburg and Berlin, in contrast to the large net outflows from the least densely populated states Mecklenburg-Vorpommern and Sachsen-Anhalt.

Chapter 3 investigates the implications of regional differences in population density for labor-market policies, more precisely, for minimum wages. Such wage limits have recently been subject of extensive political discussion in Germany. This comes as no surprise as they represent an attractive policy tool: Minimum wages are apparently targeted at fighting poverty, thus earning public respect at a direct cost that seems low. However, by its simple structure a uniform minimum wage disregards all sorts of wage structures that may exist. This includes not only wage differences associated with skills, occupation, experience, and gender, but also differences with regard to industry, firm-size, and region. The analysis concentrates on the latter point, proposing that a minimum wage is much more restrictive at the countryside than it is for workers in cities. Exploiting data from the Institute for Employment Research (IAB), the study shows that a uniform minimum wage would indeed affect regional labor markets quite distinctly. In particular, the share of workers that will be directly affected by the minimum wage is higher in rural counties as compared to cities and urban counties. Further empirical analysis shows that these rural – urban wage differences are mainly due to systematic spatial differences in wages. These results are shown to be robust to different specifications and estimation techniques. Motivated by these empirical findings, the consequences of the introduction of a uniform minimum wage in a stylized theoretical model are explored. In the spatial equilibrium model, a spatial wage distribution arises due to productivity differences and housing costs. Imposing a uniform minimum wage exerts distortive effects on the spatial structure of the economy. In particular, employment and population will rise in the more densely populated regions, implying that wages of the working population in the cities might even fall. Moreover, the population of cities would also suffer from an increase in housing costs. A welfare analysis shows that the group of workers that benefit from the minimum wage cannot compensate the others.

As outlined above, the monocentric city model incorporates commuting distance as an elementary factor of the household's location decision. In fact, commuting plays a special role as it allows households to live and work at distinct locations. The findings of Chapter 3 on the spatial wage structure in Germany indicate that this might be of particular interest in the context of urban centers and their less densely populated surroundings. A look at Figure 4.1 in Chapter 4 clearly confirms this conjecture as it articulately illustrates the importance of urban centers for commuting patterns in Germany. Further evidence is provided by the outstandingly high figures on net in-commuting into the city states Hamburg and Bremen given in column 8 of Table 1.

Chapter 4 focuses precisely on this suburb – center relation and provides a comprehensive empirical analysis of the interplay of wages, housing costs, and commuting costs in the household's location choice. Columns 6 and 7 of Table 1 give an impression of the substantial magnitudes involved when talking about commuting in Germany. After all, not less than 85% of German employees considered themselves to be commuters in 2004.[10] As mentioned before, economic theory identifies four main determinants of the location decision of individuals: Wages, housing costs, commuting costs, and the local quality of life. Thus, by incorporating commuting costs, Chapter 4 completes the economic analysis of household mobility in Germany that is conducted in this dissertation. The combined impact of these economic factors on the individual location decision is empirically quantified by the use of a discrete choice model. The analysis thereby focuses on the relation between a central urban area and its surrounding nonmetropolitan area, and examines the choice of four alternatives: To live and work in the metropolitan area; To live and work in the nonmetropolitan area; To live in the metropolitan area and commute to the nonmetropolitan area; To live in the nonmetropolitan area and work in the metropolitan area. Objects of investigation are the regional labor markets constituted by the urban centers of the largest German cities Berlin, Hamburg, and Munich. A mixed logit approach is employed where coefficients are allowed to vary randomly over decision makers instead of

[10] See Statistisches Bundesamt (2005).

being constant. This estimation strategy avoids problems involved with the restrictive independence of irrelevant alternatives (IIA) assumption, as well as with possible correlation of utility over the four alternatives. The results clearly confirm the predictions of economic theory with respect to the important roles of wages, housing costs, and commuting costs in the individual location decision. Moreover, the findings indicate a considerable degree of variation in the households' valuation of commuting- and housing costs. Estimated elasticities show how changes in wages, housing costs, or commuting time affect the distribution of households between metropolitan and nonmetropolitan areas. No systematic differences in the magnitude of the impacts between the three factors are found. The quantitative implications of the results are illustrated by simulation of two counterfactual scenarios. The scenarios aim at emulating the impacts of the planned cut in the German "Entfernungspauschale" in 2007 and of the introduction of a minimum wage as discussed in Chapter 3. Further results include the calculation of changes in consumer surplus induced by changes in wages, housing costs, and commuting costs.

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Chapter 1

Quality of Life in the Regions: Results for German Counties

Abstract*

In order to assess differences in living conditions across German regions we apply the hedonic approach of Rosen (1979) and Roback (1982) to land-price and wage differences across Germany's counties. Employing a recent survey of more than half a million Germans on a wide range of social and political issues we confirm that differences in amenities give rise to substantial differences in land prices. With regard to wages, however, we find only little effects of amenities. Relying on the land-price effects we assess the quality of life in each of the German counties and provide a comprehensive ranking.

1.1 Introduction

Differences in living conditions, land prices, and in the quality of life always capture a lot of attention by citizens and local governments in Germany as well as in other countries of the world. However, there has been little research on this issue in Germany as compared to the US, for example. This could well be due to a lower degree of household mobility. The neglect of those issues is, however, disturbing since the German systems of local public finance and fiscal federalism place a lot of emphasis on attempts to equalize living conditions across regions. Moreover, since sub-national governments consume a rather large fraction of the public sector's budget in Germany, there is much need of an evaluation of sub-national government policies and their impact on the quality of life.

Several attempts have been made to assess and compare regional growth and labor market situations and many more possibly relevant indicators of living conditions in Germany (e. g., Prognos, 2004). However, an objective assessment of living conditions faces not only substantial problems in collecting information, it also would have to make rather arbitrary assumptions about how different regional characteristics can be aggregated in

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*This chapter is based on joint work with Thiess Büttner. It is based on our paper "Quality of Life in the Regions: Results for German Counties," *Annals of Regional Science*, 43(1), 2009.

order to obtain a comprehensive assessment. Given the substantial difficulties involved we apply a market-based, hedonic, approach where problems of both, gathering information as well as aggregating regional characteristics, are solved using the revealed willingness to pay. The hedonic approach, pioneered by Rosen (1979) and Roback (1982), utilizes differences in land prices and wages across regions to infer the marginal willingness to pay for regional attributes including quantity and quality of public services. Based on corresponding estimates we follow Blomquist, Berger, and Hoehn (1988) and generate an index of the quality of life across German regions.

To the best of our knowledge no attempt has been made so far to apply this concept to German regions. This might be due to the lack of information about regional characteristics, in particular with regard to hard-to-measure public services and amenities such as safety, education, or the facilities for leisure activities. For this study we utilize a large, almost untapped, data source, the "Perspektive Deutschland" study 2004/2005,[1] a recent survey among more than half a million households on a wide range of social and political issues, and combine this with county-level data from a variety of other sources.

Our results show that, indeed, differences in amenities and disamenities do capitalize into land prices and can be used to predict a substantial part of observed land-price differences across regions, supporting the hedonic approach. With regard to wages, however, we find only little effects of amenities. Nevertheless, relying on the land-market effects of amenities a quality of life indicator is computed which ranks cities and counties. The results indicate that among the West German regions the southern regions rank highest. The regions in the East show less pronounced differences in the quality of life which to some extent reflects consistent labor market difficulties.

[1]This study was initiated and conducted by McKinsey corporation. For an overview of the project see Fassbender and Kluge (2006).

The paper proceeds as follows. The following section derives the underlying theoretical model. Section 3 briefly describes the data. Section 4 discusses the investigation approach. Section 5 presents the results from hedonic land-price and income regressions. Section 6 is concerned with the implicit prices and the quality of life index. Section 7 provides a short summary.

1.2 Theoretical Background

This section briefly reviews the basic approach to the estimation of quality of life developed by Rosen (1979) and Roback (1982). For an excellent overview see Blomquist (2006). Consider a spatial equilibrium model with several jurisdictions. Each provides specific quantities of (dis-) amenities. Land is scarce such that mobile households and firms compete for locations with high levels of amenities (low levels of disamenities). Spatial equilibrium requires household utility and production costs to be equal across jurisdictions such that there is no further arbitrage opportunity by moving. Therefore, housing costs and wages have to adjust according to the respective amenity levels at each location.

Let us assume that households have identical preferences and offer one unit of labor, each. They earn the regional wage rate w_j and consume housing h_j and a tradable good, which serves as a numeraire. For simplicity, we further assume that the price of one unit of housing is equal to the land rent r_j. Utility maximization yields an indirect utility function with the usual properties. It characterizes the combinations of private consumption and amenities for which households are indifferent between locations

$$u^* = V\left(\underbrace{w_j - r_j}_{x_j}, A_j\right), \tag{1.1}$$

where private consumption x_j is determined by the household budget constraint, $x_j = w_j - r_j$, and A_j denotes the vector of (dis-)amenities $a_{j,i}$ at location j. (Dis-)amenities increase (decrease) household utility according to

$$\frac{\partial V\left(w_j - r_j, A_j\right)}{\partial a_{j,i}} > (<)\, 0.$$

Firms produce the numeraire using local labor and land. Profit maximization requires that the unit cost are equal to the price of the numeraire such that

$$1 = c\left(w_j, r_j, A_j\right), \tag{1.2}$$

where c is the unit cost function. A regional attribute $a_{j,i}$ also can be a production (dis-) amenity, depending on its effect on the unit cost:

$$\frac{\partial c\left(w_j, r_j, A_j\right)}{\partial a_{j,i}} < (>)\, 0.$$

Spatial equilibrium is characterized by a combination of wages and rents which solves both equations simultaneously. This is illustrated graphically in Figure 1.1. For a given level of amenities A_1 in region 1, all combinations of wages and housing prices that leave the household indifferent with regard to other regions are located on the lower upward sloping line. Unit costs for the same set of attributes A_1 are depicted by the lower downward sloping line. The intersection at point a determines the equilibrium levels of housing price r_1 and wage rate w_1. The second set of curves refers to region 2 which is more attractive for households in the sense that it has more amenities and less disamenities. Formally, this case is characterized by the requirement that

$$a_{2,i} \; > \; a_{1,i} \text{ if } \frac{\partial V\left(w_j - r_j, A_j\right)}{\partial a_{j,i}} \; > \; 0, \qquad \text{and } \textit{vice versa}.$$

As a consequence, the iso-utility curve shifts up. The consequence for wages depends on whether the amenities have also effects on productivity. If there are no effects the equilibrium would be at intersection point b. In this case, land rents would be higher but wages would be reduced to maintain cost-competitiveness. The positive impact on land prices is often referred to as (cross-sectional) capitalization of amenities into the land price. Note, however, that capitalization is only partial, as wages adjust.

However, it may well be the case that amenities have productivity effects. Consider the case of positive productivity effects of amenities and negative productivity effects of dis-amenities, such that

$$a_{2,i} \;>\; a_{1,i} \qquad \text{if } \frac{\partial c\left(w_j, r_j, A_j\right)}{\partial a_{j,i}} \;<\; 0, \qquad \text{and } \textit{vice versa}.$$

Then, region 2 would be able to pay a higher land rent at the going wage rate, in other words, the iso-cost curve shifts up – the higher cost–competitiveness would show up in higher land-rents. Thus, due to the productivity effects the land-rent would be further increased. The impact on the wage rate now becomes ambiguous and we might even have a higher wage rate in equilibrium as depicted by intersection point c.

Wage and land-price effects can be used to obtain an implicit price for each amenity f_i. To see this, differentiate equation (1.1) and make use of the mobility assumption to obtain:

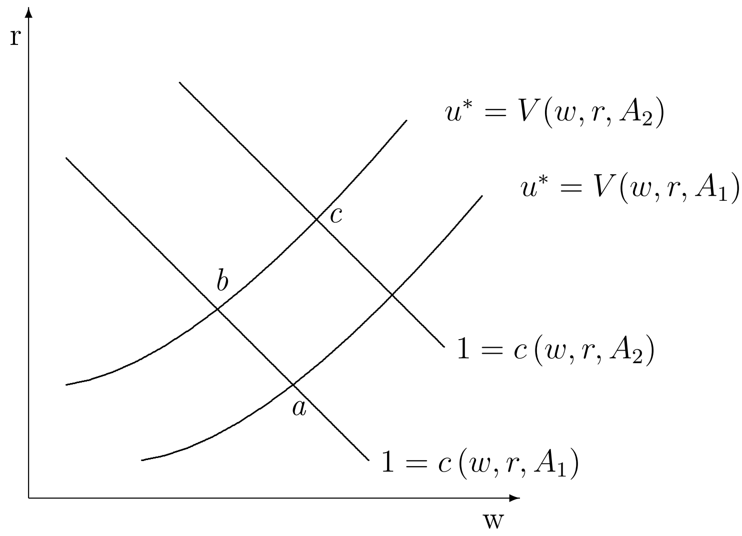
$$\frac{\partial V}{\partial x_j} dw_j - \frac{\partial V}{\partial x_j} dr_j + \frac{\partial V}{\partial a_{j,i}} da_{j,i} \;=\; 0.$$

Rearranging yields the implicit price of amenity i

$$f_i \;\equiv\; \frac{\partial V}{\partial a_{j,i}} / \frac{\partial V}{\partial x_j} \;=\; \frac{dr_j}{da_{j,i}} - \frac{dw_j}{da_{j,i}}. \tag{1.3}$$

This expression indicates that the marginal assessment of an amenity can be obtained from

Figure 1.1: Land Rent and Wage Rate in Spatial Equilibrium



the price responses of the rental price of land and the wage rate.

Given information about price responses to each of the amenities we can construct a weighted average representing the quality of life index. The index is calculated in a straightforward manner by summing over all amenities using the implicit prices as weights:

$$QOL_j = \sum_i f_i a_{ij}. \tag{1.4}$$

Based on the theory, QOL_j is an estimate of the willingness to pay for the bundle of amenities and disamenities in region j.

1.3 Investigation Approach

To obtain empirical estimates of capitalization into land prices and income effects of each amenity, we estimate hedonic land-price and income regressions.

In a first step, we regress the natural logarithm of average regional land prices on our set of regional (dis-)amenities:

$$\ln r_j = \beta_0 + \beta_1 z_j + \beta_2 A_j + \varepsilon_j, \tag{1.5}$$

where z_j is a vector of land-market characteristics and A_j is the set of (dis-)amenities in region j. However, note that there are no a-priori restrictions imposed on the parameters. In other words, we do not postulate that a region characteristic is perceived as an amenity or as a disamenity for households and/or firms. z_j captures control variables related to variations in the location rent as suggested by standard models of the urban land market (see DiPasquale and Wheaton, 1996). This includes population density as the main determinant of the location rent within metropolitan and urban areas and population growth as an indicator of the expected change in the location rent.

In a second step, we model the log of monthly net household income reported by full-time employed respondents as a function of individual characteristics like gender, education, job, etc., the number of adult household members as well as of our set of regional (dis-)amenities. The regression equation models the income of household k in region j:

$$\ln w_{k,j} = \alpha_0 + \alpha_1 x_k + \alpha_2 A_j + \alpha_3 z_j + \varepsilon_k, \tag{1.6}$$

where x_k is a vector of individual characteristics. Since data on household income is reported in income classes we use the means of these classes to construct the left-hand variable. Estimation is done using weighted least squares to take account of the sampling weights of the various types of respondents in the survey dataset. As micro data at the household level are combined with aggregate data at the regional level, inference is based on heteroscedasticity and group-correlation consistent standard errors. While the theoretical model relies on the strong assumption of perfect mobility, we experiment with different groups of households to identify possible effects of differences in household mobility.

In a third step, the coefficients (α_2, β_2) obtained are converted into implicit prices for the amenities. For this purpose, with regard to the land-price regression we need to convert the prices per sqm into monthly spending by households. To do so, we multiply the marginal land-price effect of each amenity by a factor h, which represents an estimate of the monthly housing cost associated with a land price of € 1 per squared meter.[2] The implicit price of amenity i follows from equation (1.3).

As the coefficients obtained from the hedonic regressions (1.5) and (1.6) are subject to considerable variation in their statistical significance we calculate standard errors for the implicit prices. For this purpose, we employ a Monte-Carlo simulation approach. Technically, we randomly draw 1,000 observations of each amenity coefficient from a multivariate normal distribution with an underlying variance-covariance structure equivalent to that of the respective estimation. We then apply the calculations as described above and finally get a mean value for each implicit price and its corresponding standard deviation.

[2]We use a figure of $h = .53$, which is obtained as follows: we first obtain an estimate of the average lot size used for a housing unit: for this purpose we multiply the average lot size (752.8 sqm) with 0.25 which is an estimate of the share of land typically consumed by the structure following Viejo Garcia (2003). In a second step we divide this figure by an average number of housing units per structure (1.479) taken from the Statistical Yearbook (2006). In the last step we transform each euro of land value per sqm into monthly cost by fixing the rate of interest at 0.05 and dividing by 12.

1.4 Data and Descriptive Statistics

While the above approach has been applied several times to US data, to the best of our knowledge no attempt has been made so far to apply the quality of life concept to German regions. This study is concerned with the county-level in Germany which comprises 116 unincorporated cities, sometimes referred to as urban counties, and 323 counties. The latter are larger administrative units incorporating, on average, 38 municipalities.

Table 1.1 presents summary statistics for land prices, household income, amenities, and control variables. The data is obtained from a variety of sources. Data on land prices comes from the German federal and regional statistical offices and refers to transactions of land available for construction. Land prices are calculated as average prices per sqm sold in 2001 – 2003 in each county.[3]

Data on household income as well as on several amenities is based on the "Perspektive Deutschland" study 2004, a large survey among more than half a million Germans. It reports opinions and valuations of German residents concerning a variety of aspects of life in Germany and the German regions, respectively. Along with this information, the data set contains information on household income, age, education, local neighborhood, job, etc. Representativeness is ensured by sampling weights drawn from a parallel field-survey with more than 10,000 participants. The regression analysis of the wage equation as well as the aggregation of survey responses at regional level both take account of these sampling weights to correct for participation bias.

Information on monthly household income is reported in eleven income intervals (see Appendix) net of taxes and including transfers. In order to reduce possible problems with

[3]Most data points are three-year averages. However, some data is missing for privacy reasons and we use 2004 land prices to obtain three- or at least two-year averages where possible.

the differences in hours worked we focus on full-time employed individuals in our analysis. We use the means of each income class as dependent variable in our hedonic income estimation. However, the highest interval is top-coded, *i. e.* it has no explicit upper bound. We therefore follow Cowell (2000) and assume that the distribution of household income is Paretian over the highest two intervals. Fitting the distribution to our data gives an estimate of the Paretian shape parameter $a > 1$, which allows us to obtain an estimate of the mean of the highest income class.[4]

To capture the residents' living conditions we use data from the same survey and compute indicators of the assessment of the region in terms of security and crime, education, cultural and leisure facilities, the local market for labor, as well as accessibility and traffic conditions. In the survey, these variables show the value 1 if the participant considers the aspect in question as being one of the four most urgent problems to be dealt with in her/his residential region. For our purposes, the individual assessments are aggregated at the county level. To facilitate interpretation we recode the variables, such that our regressors take values between zero and one, where a higher value indicates a better situation or less need for improvement (except for crime, where a higher value indicates a worse situation). Formally, we aggregate over individual assessments of amenity i in region j by

$$\frac{1}{\sum_{k=1}^{n_j} \mathsf{w}_{k,j}} \sum_{k=1}^{n_j} \mathsf{w}_{k,j} \left(\text{“Urgent problem”}_{k,j,i} = 0 \right),$$

where i refers to the variables leisure facilities, accessibility, education, and local labor market, and $\mathsf{w}_{k,j}$ is the respondent's sampling weight. "urgent problem"$_{k,j,i} = 0$ indicates that respondent k from region j considers i not to be an urgent problem.[5] An additional

[4]We obtain a shape parameter of the Pareto distribution of the highest two intervals of $a = 5.04$, resulting in a mean of the highest income class of $\widehat{w} = 7484.62$. For the sample of mobile households we have $a = 5.03$ and $\widehat{w} = 7487.85$. See Cowell (2000), p.156f, for more details.

[5]To obtain an indicator for crime we simply sum whether the respondent *is* considering crime as an urgent problem.

labor market indicator is designed specifically to capture the existence of job alternatives within the region. This indicator captures the individuals' expectations of whether an adequate job would be found in the region in case of job loss. The individual response takes the value unity if the answer is yes and zero otherwise. Individual assessments are aggregated simply as the weighted sum

$$\frac{1}{\sum_{k=1}^{n_j} \mathsf{w}_{k,j}} \sum_{k=1}^{n_j} \mathsf{w}_{k,j} \left(\text{“Altern. job opportunities exist”}_{k,j} = 1\right),$$

where “Altern. job opportunities exist”$_{k,j} = 1$ indicates that respondent k from region j expects to find an alternative job opportunity.

Further amenity data relates to climate and environment. The data on sunshine comes from the Federal Meteorological Office (“Deutscher Wetterdienst”). It reports the average annual duration of sunshine in 2004 in 100 hours measured at one observatory in each county. Data on industry emissions stems from federal and states' statistical offices and utilizes information about the average emission of CH4, NOx and SO2 particles in 27 industry branches on a per-worker basis. For each county, we calculate total emission in tons per sqkm using local employment in these industries. Further variables capture the area covered by forests or water as a fraction of total county area. Another variable reports the number of overnight stays and is used to capture regions specialized in tourism. Some further variables capture possible advantages from living in or close to metropolitan areas which might relate not only to productivity advantages of agglomerations but also to consumption advantages.[6] Metropolitan area is a binary variable reflecting the classification of the Federal Bureau of Regional Planning (“Bundesamt für Bauwesen und Raumordnung”). An indicator of the peripherality is taken from the same source and reports the average travel time to the next three agglomeration centers in minutes. Finally, as an

[6]For a discussion see Rosenthal and Strange (2004) and Dalmazzo and de Blasio (2007).

indicator of social problems, a local poverty variable is added capturing the number of welfare recipients per resident.

Moreover, we use a couple of control variables. In the land price regressions, population density and population growth are used to capture differences in the location rent and are obtained from the states' statistical offices. The analysis of cross-sectional income differences includes several individual characteristics following the standard Mincer-type wage regression at the individual level. This includes indicators of nationality, family status, gender, age, and education. A further variable captures the size of the household of the respondent. In order to make sure that the specific situation in eastern Germany does not affect the results we include a binary variable for counties in the eastern part of the country capturing the former German Democratic Republic and Berlin. Since unincorporated cities and counties are different administrative units we also include a binary variable which is unity for rural counties (as opposed to urban counties). Furthermore, an interaction term is added capturing the city/county difference in the eastern part of the country.

1.5 Regression Results

Table 1.2 reports the results of hedonic regressions of land prices and household income on the set of amenities. The results for the land-price regressions are reported in Column (1). Except for education and the dummies for metropolitan area and rural county, all amenities show a significant impact on the log of the land price. The signs are as expected: the price for land is higher in regions with more sunshine, more appeal to tourists, or good traffic connections, whereas high levels of industry emissions or perceived crime tend to reduce the price. Strong effects are also exerted from the local labor market conditions and the existence of alternative job opportunities within the region – the positive coefficients of the

Table 1.1: Descriptive Statistics

Variable	Mean	Std.Dev.	Min	Max
	Survey data "Perspektive Deutschland"			
Leisure facilities	.784	.071	.523	.957
Crime	.185	.076	.032	.480
Accessibility	.720	.126	.275	.973
Education	.694	.067	.481	.883
Local labor market	.272	.158	.006	.724
Altern. job opport.	.097	.049	.002	.254
Household income	2456	5.91	250	7485
HH income (mobile sample)	2491	7.69	250	7488
	County characteristics			
Sunshine	16.2	1.19	10.5	18.9
Industry emissions	6.06	9.97	.061	80.2
Share of forest	27.4	15.2	.800	64.8
Share of water	2.48	3.07	.200	28.8
Tourism	4.48	6.50	.200	76.9
Met.area	.352	.478	0	1
Peripherality	104	38.3	24	258
Poverty	29.3	16.2	3.50	118.5
East	.256	.437	0	1
Rural	.733	.443	0	1
Rural x East	.194	.396	0	1
Population growth	.535	6.05	-25	19.4
Density	5.08	6.55	.398	40.2
Land price	119	111	15.0	979

See text for description. Statistics for 438 counties. Figures on individual household income are weighted and refer to 211216 weighted observations in the full sample and 127828 weighted observations in the sample of mobile households, respectively.

respective variables are highly significant. The overall predictive power of the regression is quite good: about 90% of observed differences in the land price across German counties can be predicted from the local amenities and further controls.

The results from the income regression are provided in Column (2). Note that the estimates are obtained from a weighted-least squares approach where individual observations are weighted with the sampling probability. The Mincer-type variables show highly significant coefficients with the expected sign for all of the individual characteristics. However, the amenity variables prove mostly insignificant. Only the labor-market situation shows a significant positive effect.[7] While this is at odds with the existence of compensating wage differentials it should not be overemphasized since respondents may take the regional wage level into account when assessing the local labor market conditions. Moreover, the second labor market indicator which is more precisely asking for job opportunities is not significant. A significant positive effect is obtained only for the indicator for metropolitan areas which possibly points at some agglomeration effects.[8]

Note that the dummy for eastern German counties remains significantly negative in both regressions. This indicates that the differentials in land prices and income between western and eastern Germany cannot be fully explained by amenity differences or by differences in the labor-market situation. This might point to some omitted amenities favoring West Germany's regions. However, an alternative explanation might relate to transition problems in the East.

Since the data on land prices used in this study reflect actual transactions of land ready

[7] The insignificance of population growth might reflect some simultaneity bias due to correlation between population growth and the wage level. However, the results from alternative regressions where the population growth variable is omitted do not show major differences with regard to the other coefficients.

[8] The size of the coefficient points at an urban income premium of about 3%. Lehmer and Möller (2007) find a wage premium of 8%. However, note that our study is concerned with household income net of taxes and including transfers.

Table 1.2: Regression Results

Variable	log Landprice (€ /sqm) (1)		log Household Inc. (net) (2)	
Region Characteristics				
Leisure facilities	1.55***	(.279)	.103	(.057)
Crime	-.815**	(.266)	-.054	(.045)
Accessibility	.664***	(.155)	-.044	(.036)
Education	.034	(.250)	.008	(.061)
Local labor market	1.03***	(.209)	.201***	(.038)
Altern. job opport.	2.09***	(.542)	.090	(.108)
Sunshine	.038**	(.012)	.004	(.003)
log Ind. emissions	-.086**	(.030)	-.001	(.006)
Share of forest	.006***	(.001)	.000	(.000)
Share of water	.020***	(.005)	.000	(.001)
Tourism	.010***	(.002)	-.001	(.001)
Met.area	.049	(.032)	.028***	(.007)
Peripherality	-.001*	(.001)	-.000	(.000)
Poverty	-.004*	(.001)	.000	(.000)
East	-.456***	(.075)	-.103***	(.020)
Rural	-.058	(.065)	.011	(.014)
Rural x East	.189*	(.076)	-.022	(.018)
Region Controls				
Population growth	.018***	(.003)	.002	(.001)
log Density	.561***	(.058)	-.000	(.010)
Individual Characteristics				
German			.065***	(.015)
Married			.232***	(.005)
Female			-.073***	(.005)
Year of birth			.050***	(.007)
Year of birth sqrd			-.002**	(.001)
Education			.080***	(.007)
Education sqrd.			-.002***	(.000)
No. of household members			.074***	(.003)
R^2	.898		.334	

Results for the land price are obtained from least squares estimation with 435 observations; heteroskedasticity robust standard errors in parentheses. The income regression results are obtained using weighted-least squares with weights for individual sampling probabilities. Sum of weighted observations: 211190. Robust standard errors clustered at region level in parentheses. * denotes significance at the 10% level (** at 5%, *** at 1% level).

Table 1.3: Income Regression: Further Results

Variable	log Household Inc. (net) complete sample (1)		log Household Inc. (net) sample of mobile Households (2)	
Region Characteristics				
Leisure facilities	.103	(.057)	.190**	(.073)
Crime	-.054	(.045)	-.022	(.053)
Accessibility	-.044	(.036)	-.060	(.040)
Education	.008	(.061)	.040	(.069)
Local labor market	.201***	(.038)	.160***	(.046)
Altern. job opport.	.090	(.108)	.077	(.127)
Sunshine	.004	(.003)	.006*	(.003)
log Ind. emissions	-.001	(.006)	.005	(.007)
Share of forest	.000	(.000)	.000	(.000)
Share of water	.000	(.001)	.000	(.001)
Tourism	-.001	(.001)	.000	(.001)
Met.area	.028***	(.007)	.035***	(.009)
Peripheral	-.000	(.000)	-.000	(.000)
Poverty	.000	(.000)	.000	(.000)
East	-.103***	(.020)	-.084***	(.019)
Rural	.011	(.014)	.012	(.015)
Rural x East	-.022	(.018)	-.032	(.019)
Region Controls				
Population growth	.002	(.001)	.002*	(.001)
log Density	-.000	(.010)	-.009	(.012)
Individual Characteristics				
German	.065***	(.015)	.067***	(.015)
Married	.232***	(.005)	.236***	(.006)
Female	-.073***	(.005)	-.081***	(.006)
Year of birth	.050***	(.007)	.047***	(.010)
Year of birth sqrd	-.002**	(.001)	-.001	(.001)
Education	.080***	(.007)	.078***	(.009)
Education sqrd.	-.002***	(.000)	-.002***	(.000)
No. of household members	.074***	(.003)	.082***	(.003)
R^2	.334		.350	

Weighted least squares estimates with weights for individual sampling probabilities. Robust, clustered standard errors in parentheses. * denotes significance at the 10% level (** at 5%, *** at 1% level). Complete sample: sum of weighted observations: 211190. Sample of mobile HH: sum of weighted observations: 127820.

for construction, it makes sense to argue that, as it reflects location decisions, it may well be representing decisions where mobility is important. This is different with the income data which simply report the earnings of the current population. Hence, lack of household mobility might be much more important in the income regressions. The second column of Table 1.3 reports results obtained using a sub-sample of households that have explicitly expressed a higher willingness to move in the survey.[9] For ease of comparison, the first column repeats the above results. As can easily be seen, most of the amenities still prove insignificant. Only leisure facilities and sunshine now exert positive effects on the wage level. However, also the positive coefficient of the local labor market indicator is confirmed.

1.6 Implicit Prices and Quality of Life Index

As discussed above, in order to obtain the implicit price of an amenity the standard approach does not only consider the land-price effect but also the income effect of the amenity. For most amenities, however, the above results confirm only land-price effects. Apart from the labor market variable, significant income effects have only been found for metropolitan regions, sunshine, and leisure facilities. An attempt to incorporate those income effects, however, faces problems. To see this, consider, for instance, the sunshine variable. Sunshine exerts a positive impact on the land price. Let us ignore for a moment the income effect of sunshine. Evaluating the point estimate of the semi-elasticity at the mean land-price we obtain an implicit price of € 2.40 per 100 hours of sunshine per year. However, in the income regression for the mobile households we obtain a positive income effect. This suggests that the implicit price of sunshine might be overestimated. To see this assume that the income effect would amount to the same value, *i. e.* € 2.40. Then, the land price effect

[9]More precisely, the sub-sample consists of people who responded positively to the survey question "Could you basically imagine to move to a region that is located at a distance of more than 100 km from your current residence?"

of sunshine would simply reflect the income effect, in other words, the direct utility impact of sunshine would be zero in this case. Evaluating the point estimate of the semi-elasticity of sunshine in the income regression at the mean income level we find that the income effect of 100 hours of sunshine is € 14.95. As a consequence, if we base the calculation of the implicit price on the difference of land-price and income effects, we would assign a negative price to sunshine: an increase of the hours of sunshine would exert a depressing effect on utility. Applying the same procedure to leisure facilities would similarly suggest that better leisure facilities would deteriorate the quality of life. The relative strength of land-price and income effects depends crucially on the factor by which price effects on land are translated into monthly housing cost. Therefore, the unconvincing results may just be a result of a too small translation factor. However, it is also disturbing that the income regression does not point at any compensating income differentials. One might speculate whether this results from specific institutions in the labor market. Another, more simple explanation is that the income data available to our study is somewhat flawed as it is reported net of taxes and including transfers.

Facing those difficulties we compute implicit prices solely on basis of the land-price regression. In terms of equation (1.3) this implies to set $\frac{dw_j}{da_{j,i}} = 0$. Table 1.4 reports the resulting implicit prices for the amenities. The values in parentheses give the standard deviations of the prices obtained in our Monte-Carlo simulation to account for differences in statistical significance.

The figures report the price per month. For example, the results suggest that households are willing to pay around € 2.40 per month to enjoy one hundred additional hours of sunshine per year. To illustrate the magnitude the last column of Table 1.4 reports the difference in the quality of life between the top 10 regions in the respective category and the mean. Accordingly, compared with a region with average hours of sunshine the quality of life is higher by about € 5.89 per month. In other words, households would be willing to pay about € 5.89 per month in order to enjoy the longer sunshine per year which is experienced in the ten regions with most hours of sunshine relative to the mean. Thus, combining implicit prices with the observed variation in amenities this column allows us to see what is mainly driving the quality of life differences. Generally, we can see that on the one hand quality of life differences are driven by geographical disposition, leisure facilities, and touristic amenities. On the other hand, the labor market conditions are quite important.

Another important difference in the quality of life relates to the situation in the eastern or western part of the country. However, the dummy for the eastern part of the country may simply reflect the incapability to adequately capture all possible regional amenities.

Table 1.5 summarizes the results for the quality of life index for each of the four groups of regions. Accordingly, the differences in the quality of life are most significant among counties in West Germany. The differences in East Germany are much less pronounced. Within the group of West German cities (urban counties) the maximal difference in the quality of life amounts to € 154 per month.

Table 1.6 in the Appendix reports the quality of life index for each county. The table also shows the complete ranking of the counties in eastern and western Germany according to the index. Figures 1.2 and 1.3 report the results graphically. For West Germany Figure 1.2 shows that the southern part of the country exhibits the highest figures for the quality of life, whereas the northern regions tend to show much lower figures. For East Germany the quality of life differences are less spatially concentrated. This could possibly reflect the fact that labor market conditions are equally difficult in most regions in the East and, hence, geographical conditions might dominate.

Table 1.4: Implicit Prices (monthly figures in €)

Variable	Price	(Std.err)	Top vs. Average
Leisure facilities	97.9	(18.1)	14.8
Accessibility	41.7	(9.67)	9.28
Education	2.16	(15.3)	.325
Crime	-52.1	(16.5)	6.93
Local labor market	64.8	(13.2)	24.9
Altern. job opport.	131.4	(35.1)	17.0
Sunshine	2.40	(.782)	5.89
Ind. emissions	-.903	(.319)	5.33
Share of forest	.347	(.063)	12.1
Share of water	1.27	(.337)	19.6
Tourism	.610	(.139)	19.2
Met.Area	3.10	(2.02)	2.01
Peripherality	-.074	(.037)	5.16
Poverty	-.234	(.091)	5.48
East	-28.7	(4.69)	21.4
Rural	-3.39	(4.10)	.905
Rural x East	11.8	(4.67)	9.52

Table 1.5: Descriptive Statistics on the Quality of Life (monthly figures in €)

Sub-sample	Mean	Std.Dev.	Min	Max
Rural counties (West)	170	22.7	120	245
Urban counties (West)	159	24.7	76	230
Rural counties (East)	126	12.5	98	175
Urban counties (East)	124	18.1	90	158

Calculations are based on the implicit prices according to the land-price effects. The list of amenities considered includes Tourism, Met.area, Peripheral, Rural, East, Rural x East, Poverty, Share of water, Share of forest, Leisure facilities, Accessibility, Education, Crime, Industry emissions, Local labor market, Alternative job opportunities, and Sunshine.

1.7 Summary

In order to derive a comprehensive set of indicators of the quality of life in the German regions, we adopt a market-based, hedonic, approach where the problem of aggregation of various dimensions of the quality of life is solved using the revealed willingness to pay. Following Rosen (1979) and Roback (1982), we utilize differences in land prices and incomes across regions to infer the marginal willingness to pay for regional attributes including quantity and quality of public services.

Based on estimates of the cross-sectional capitalization of amenities into land prices and incomes we follow Blomquist, Berger, and Hoehn (1988) and generate an index of the quality of life across German regions. For this study, we utilize a large, almost untapped, data source, the "Perspektive Deutschland" study 2004/2005, a recent survey among more than half a million households on a wide range of social and political issues, and combine this with county-level data from a variety of other sources.

Our results show that, indeed, differences in amenities and disamenities do capitalize into land prices, supporting the hedonic approach to land prices. In fact, the land-price regression allows us to predict about 90% of the observed land-price differences across German counties. However, with regard to income we fail to detect effects of most amenities: income regressions do not point at any compensating income differentials. This finding proves to be robust even when focusing on households with higher mobility. One might speculate whether this results from specific institutions in the labor market. Yet, a more simple explanation is that the income data available to our study fails to detect compensating wage effects as it reports household income net of taxes and including transfer income. Given this data limitation, it is left for future research to further discuss the existence of compensating wage differentials across regions in Germany.

Relying on land price capitalization we obtain implicit prices for each of the amenities. Taking into account the observed differences we find that quality of life differences are mainly driven by two sets of amenities. The first refers to geographical conditions, leisure facilities, and touristic amenities. The second set relates to local labor market conditions. Interestingly, the results confirm a strong effect on the quality of life not only for labor market conditions in general but also for the expectation to find an alternative employment opportunity in the same region.

Finally, we derive a quality of life index for all German counties and cities. Accordingly, among the regions in West Germany the southern counties, particularly those in the Munich area, as well as in Baden-Württemberg show the highest quality of life. For East Germany the quality of life differences are less concentrated spatially.

Acknowledgements

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Appendix: Datasources and Definitions

Survey data on urgent problems are taken from the "Perspektive Deutschland" study 2004 and are based on answers to the question "which is the issue to be improved most urgently in your region?" The original variable takes the value unity if the aspect in question is considered one of the four most urgent problems in the region. We calculate the average assessment of each aspect in each county. We recode the variables, such that our regressors take values between 0 and 1, where a higher value indicates a better situation or less need for improvement (except for crime, where a higher value indicates a worse situation). The interpretation of the derived variables is:

Leisure facilities : local cultural and leisure facilities are considered as satisfactory.

Crime: crime is considered to be one of the four most urgent problems in the region.

Accessibility: local traffic system/connection to other regions is considered as satisfactory.

Education: local schooling/education facilities are considered as satisfactory.

Local labor market: local market for labor is considered as satisfactory.

Data on **alternative job opportunities** is also taken from the "Perspektive Deutschland" study 2004 and is based on answers to the question "in the case of loosing your job: will you be able to find an equally good job in your region within reasonable time?" The original variable takes the value unity if the answer is yes and zero otherwise. We calculate the average of all answers within each county.

Household income: net household income net of taxes and including transfers in € per month, grouped in eleven income classes as follows. Taken from the Perspektive Deutschland study 2004.

1	0 € – 500 €
2	500 € – 899 €
3	900 € – 1,299 €
4	1,300 € – 1,499 €
5	1,500 € – 1,999 €
6	2,000 € – 2,599 €
7	2,600 € – 3,199 €
8	3,200 € – 4,499 €
9	4,500 € – 5,499 €
10	5,500 € – 5,999 €
11	more than 6,000 €

Sunshine : average yearly duration of sunshine in 100 Hrs., measured at, at least, one meteorological office in each county. For counties with missing information the value of the closest neighboring county is used. Taken from "Deutscher Wetterdienst" (2004).

Emissions: aggregate emission of CH4, NOx and SO2 particles of 27 industry branches in tons per sqkm. Calculations based on average emissions per worker of each industry branch and regional occupation figures of the sectors. Data taken from the states' statistical offices (2004).

Share of forest: forest area as a share of the total surface area in percent. Taken from the states' statistical offices (2000).

Share of water: water area as a share of the total surface area in percent. Taken from the states' statistical offices (2000).

Tourism: number of overnight stays per inhabitant. Taken from the Federal Statistical Office and States' statistical offices (2003).

Metropolitan area: dummy variable that takes the value unity if a region belongs to a metropolitan area according to the classification of the "Bundesamt für Bauwesen und Raumordnung". Taken from the "Perspektive Deutschland" study 2004.

Peripherality: average travel time in minutes to the next three agglomeration centers by public transport. Source: "Bundesamt für Bauwesen und Raumordnung."

Poverty: number of welfare recipients ("Sozialhilfeempfänger") per 1,000 inhabitants. Taken from the Federal Statistical Office and States' statistical offices (2003).

East: dummy variable that takes the value unity if a region is situated in eastern Germany.

Rural: dummy variable that takes the value unity if a region is a rural county.

Rural x East: dummy variable that takes the value unity if a region is a rural county situated in eastern Germany.

Population growth: population growth in percent. Taken from the Federal Statistical Office and States' statistical offices (2003).

Density: population density in 100 persons per sqkm. Taken from the states' statistical offices (2004).

Land price: three-year average price in € per sqm land sold. Mostly calculated with data from 2001 – 2003, data on 2004 or two-year averages are used where information is missing. Taken from the states' statistical offices.

Table 1.6: Ranking of Counties and Quality of Life (monthly figures in €)

Pos.	County/City	QOL	Pos.	County/City	QOL
	West German counties		119	Freyung-Grafenau	167
1	Starnberg	245	120	Altötting	167
2	München	239	121	Rhein-Hunsrück	167
3	Miesbach	232	122	Coesfeld	167
4	Bad Tölz	232	123	Düren	166
5	Freising	229	124	Gifhorn	166
6	Garmisch-P.	225	125	Rottal-Inn	166
7	Fürstenfeldbruck	216	126	Rhein-Lahn	166
8	Ebersberg	216	127	Viersen	166
9	Oberallgäu	215	128	Dingolfing	166
10	Bad Dürkheim	213	129	Lahn-Dill	165
11	Landsberg a.L.	212	130	Cochem-Zell	165
12	Hochtaunus	210	131	Trier-Saarburg	165
13	Karlsruhe	209	132	Bayreuth	165
14	Esslingen	208	133	Wesel	165
15	Rems-Murr	207	134	Aachen	164
16	Breisgau	207	135	Uelzen	164
17	Weilheim	207	136	Paderborn	164
18	Böblingen	205	137	Gütersloh	164
19	Erlangen	204	138	Mühldorf a.Inn	164
20	Aschaffenburg	203	139	Mayen-Koblenz	164
21	Rastatt	202	140	Main-Tauber	164
22	Erding	202	141	Neckar-Odenw.	163
23	Ludwigsburg	202	142	Limburg-Weilburg	163
24	Rhein-Neckar	202	143	Helmstedt	162

Continued on next page

Pos.	County/City	QOL	Pos.	County/City	QOL
25	Dachau	201	144	Lichtenfels	162
26	Rosenheim	201	145	Neunkirchen	162
27	Berchtesgadener L.	200	146	Euskirchen	161
28	Main-Taunus	198	147	Westerwald	161
29	Freudenstadt	197	148	Bad Kreuznach	161
30	Aichach-Friedberg	197	149	Amberg-Sulzbach	161
31	Rheingau-Taunus	196	150	Goslar	161
32	Bodenseekreis	194	151	Kleve	160
33	Nürnberger L.	194	152	Oberbergisch.	160
34	Ostallgäu	194	153	Hochsauauerland	160
35	Tübingen	194	154	Sigmaringen	160
36	Roth	194	155	Heidenheim	160
37	Tuttlingen	194	156	Segeberg	159
38	Biberach	194	157	Südwestpfalz	159
39	Darmstadt	193	158	Steinfurt	159
40	Calw	193	159	Rendsburg	159
41	Unterallgäu	193	160	Fulda	158
42	Eichstätt	193	161	Neuwied	158
43	Neu-Ulm	192	162	Cham	157
44	Rhein-Pfalz	191	163	Schaumburg	157
45	Main-Kinzig	191	164	Peine	157
46	Göppingen	190	165	Herford	157
47	Lörrach	190	166	Wolfenbüttel	157
48	Traunstein	189	167	Diepholz	157
49	Konstanz	188	168	Oldenburg	157
50	Emmendingen	188	169	Osnabrück	157
51	Germersheim	188	170	Märkischer K.	157

Continued on next page

Pos.	County/City	QOL	Pos.	County/City	QOL
52	Mainz-Bingen	188	171	Lippe	156
53	Groß-Gerau	187	172	Marburg-Biedenkopf	156
54	Augsburg	187	173	Daun	156
55	Fürth	187	174	Plön	155
56	Offenbach	187	175	Soest	155
57	Alb-Donau	186	176	Odenwald	154
58	Rottweil	186	177	Göttingen	154
59	Pfaffenhofen	186	178	Vechta	154
60	Südl. Weinstraße	185	179	Recklinghausen	154
61	Miltenberg	185	180	Hof	153
62	Ortenau	185	181	Schwandorf	153
63	Heilbronn	184	182	Borken	153
64	Neuburg-Sch.	184	183	Höxter	153
65	Enzkreis	184	184	Minden-Lübbecke	153
66	Rhein-Sieg	184	185	Deggendorf	153
67	Hohenlohe	184	186	Soltau	152
68	Wetterau	183	187	Bad Kissingen	152
69	Forchheim	183	188	Waldeck-Frankenberg	152
70	Bamberg	182	189	Verden	152
71	Schwarzwald	182	190	Hildesheim	152
72	Ravensburg	182	191	Bentheim	151
73	Landshut	181	192	Stade	151
74	Regensburg	181	193	Emsland	151
75	Rheinisch-Berg.	181	194	Saarlouis	150
76	Lindau	180	195	Hameln-Pyrmont	150
77	Passau	180	196	Rotenburg	150
78	Main-Spessart	179	197	Schwalm-Eder	150

Continued on next page

Pos.	County/City	QOL	Pos.	County/City	QOL
79	Würzburg	179	198	Unna	149
80	Bergstraße	179	199	Schweinfurt	149
81	Kelheim	178	200	Warendorf	149
82	Ostalbkreis	176	201	Heinsberg	148
83	Kitzingen	176	202	Kassel	148
84	St. Wendel	176	203	Wittmund	148
85	Waldshut	176	204	Ammerland	146
86	Straubing	176	205	Schleswig-Flensburg	146
87	Neuss	175	206	Bitburg-Prüm	146
88	Reutlingen	175	207	Friesland	146
89	Olpe	175	208	Werra-Meißner	145
90	Stormarn	174	209	Kulmbach	144
91	Neumarkt i.d.OPf.	174	210	Leer	144
92	Ahrweiler	173	211	Celle	144
93	Bernkastel	173	212	Neustadt a.d.W.	144
94	Ostholstein	173	213	Osterholz	142
95	Weißenburg	172	214	Steinburg	142
96	Nordfriesland	172	215	Hersfeld-Rotenburg	142
97	Regen	172	216	Donnersberg	141
98	Pinneberg	171	217	Dithmarschen	141
99	Donau-Ries	171	218	Haßberge	140
100	Schw. Hall	170	219	Kronach	139
101	Dillingen a.d.D.	170	220	Wunsiedel i.F.	138
102	Hannover	169	221	Tirschenreuth	138
103	Harburg	169	222	Northeim	138
104	Günzburg	169	223	Altenkirchen	137
105	Ennepe	169	224	Osterode	137

Continued on next page

Pos.	County/City	QOL	Pos.	County/City	QOL
106	Ansbach	169	225	Cuxhaven	137
107	Neustadt a.d.A.	168	226	Kusel	136
108	Zollernalbkreis	168	227	Aurich	136
109	Erftkreis	168	228	Cloppenburg	135
110	Mettmann	168	229	Birkenfeld	134
111	Saarpfalz	168	230	Coburg	133
112	Herzogtum Lauenburg	168	231	Wesermarsch	133
113	Kaiserslautern	167	232	Nienburg	132
114	Lüneburg	167	233	Rhön-Grabfeld	130
115	Gießen	167	234	Vogelsberg	128
116	Alzey-Worms	167	235	Lüchow	126
117	Siegen-Wittg.	167	236	Holzminden	120
118	Merzig-Wadern	167			
	West German cities		46	Worms	158
1	Baden-Baden	230	47	Hamm	158
2	Karlsruhe	217	48	Braunschweig	157
3	Heidelberg	213	49	Mannheim	156
4	Bonn	205	50	Lübeck	156
5	Freiburg im Breisgau	198	51	Offenbach	153
6	Darmstadt	198	52	Leverkusen	153
7	Wiesbaden	194	53	Solingen	152
8	Neustadt	191	54	Bottrop	151
9	Landau	190	55	Duisburg	151
10	Rosenheim	188	56	Oldenburg	150
11	Münster	188	57	Dortmund	150
12	München	187	58	Frankenthal	150
13	Aschaffenburg	184	59	Bamberg	150

Continued on next page

Pos.	County/City	QOL	Pos.	County/City	QOL
14	Speyer	184	60	Krefeld	150
15	Kempten	183	61	Kaufbeuren	150
16	Stuttgart	183	62	Nürnberg	148
17	Pforzheim	178	63	Straubing	148
18	Düsseldorf	177	64	Ingolstadt	147
19	Köln	176	65	Regensburg	147
20	Hamburg	176	66	Zweibrücken	147
21	Frankfurt a.M.	176	67	Mönchengladbach	146
22	Würzburg	175	68	Bochum	145
23	Ulm	175	69	Weiden	145
24	Mainz	174	70	Wuppertal	144
25	Landshut	172	71	Kiel, Landeshauptstadt	142
26	Mülheim	170	72	Remscheid	142
27	Fürth	170	73	Flensburg	139
28	Memmingen	170	74	Bremen	138
29	Erlangen	169	75	Delmenhorst	137
30	Kaiserslautern	169	76	Bremerhaven	137
31	Oberhausen	167	77	Gelsenkirchen	134
32	Schwabach	166	78	Herne	134
33	Saarbrücken	166	79	Hof	133
34	Passau	165	80	Kassel	131
35	Trier	164	81	Emden	130
36	Koblenz	163	82	Neumünster	128
37	Essen	163	83	Wilhelmshaven	127
38	Wolfsburg	163	84	Salzgitter	126
39	Bielefeld	162	85	Amberg	125
40	Ansbach	162	86	Bayreuth	121

Continued on next page

Pos.	County/City	QOL	Pos.	County/City	QOL
41	Augsburg	160	87	Coburg	118
42	Aachen	160	88	Ludwigshafen	114
43	Heilbronn	160	89	Pirmasens	114
44	Hagen	159	90	Schweinfurt	76
45	Osnabrück	159			
	East German counties		43	Sonneberg	124
1	Rügen	175	44	Bitterfeld	124
2	Potsdam	159	45	Märkisch-Oderl.	124
3	Wernigerode	150	46	Saalkreis	124
4	Dahme-Spreewald	148	47	Vogtland	124
5	Müritz	148	48	Oberspreewald	124
6	Sächsische Schweiz	148	49	Ostprignitz	124
7	Bad Doberan	145	50	Anhalt-Zerbst	124
8	Barnim	143	51	N.W.Mecklenburg	124
9	Ostvorpommern	141	52	Spree-Neiße	122
10	Meißen	139	53	Döbeln	122
11	Oberhavel	139	54	Nordhausen	122
12	Parchim	139	55	Burgenland	121
13	Mecklenburg-Strelitz	138	56	Altenburger L.	121
14	Ohrekreis	138	57	Muldental	121
15	Delitzsch	136	58	Torgau-Oschatz	120
16	Teltow-Fläming	136	59	Schönebeck	120
17	Oder-Spree	135	60	Ludwigslust	119
18	Gotha	135	61	Prignitz	119
19	Leipziger L.	135	62	Hildburghausen	119
20	Havelland	134	63	Mittl. Erzgebirg	119
21	Chemnitzer L.	134	64	Aue-Schwarzenberg	119

Continued on next page

Pos.	County/City	QOL	Pos.	County/City	QOL
22	Ilm-Kreis	133	65	Köthen	118
23	Uckermark	132	66	Elbe-Elster	118
24	Uecker-Randow	132	67	Weißenfels	117
25	Nordvorpommern	132	68	Annaberg	117
26	Saale-Holzland	132	69	Sömmerda	117
27	Bördekreis	131	70	Quedlinburg	117
28	Greiz	130	71	N. Oberlausitz	117
29	Bautzen	130	72	Mansfelder L.	116
30	Riesa	129	73	Merseburg	115
31	Sangerhausen	129	74	Mittweida	115
32	Wartburg	128	75	Saale-Orla	114
33	Saalfeld	128	76	Eichsfeld	112
34	Güstrow	128	77	Aschersleben	111
35	Kamenz	127	78	Altmark	110
36	Stollberg	127	79	Bernburg	109
37	Jerichower L.	126	80	Kyffhäuser	109
38	Freiberg	126	81	Stendal	108
39	Schmalkalden	125	82	Demmin	107
40	Weimarer L.	125	83	Löbau-Zittau	107
41	Wittenberg	125	84	Unstrut-Hainich	103
42	Weißeritz	124	85	Halberstadt	98
East German cities			14	Leipzig	126
1	Potsdam	158	15	Suhl	126
2	Brandenburg	158	16	Magdeburg	122
3	Frankfurt a.d.O.	156	17	Cottbus	121
4	Weimar	140	18	Chemnitz	116
5	Dresden	138	19	Halle	115

Continued on next page

Pos.	County/City	QOL	Pos.	County/City	QOL
6	Schwerin	138	20	Gera	113
7	Jena	136	21	Stralsund	113
8	Rostock	131	22	Plauen	112
9	Berlin	131	23	Greifswald	110
10	Eisenach	131	24	Wismar	99
11	Neubrandenburg	127	25	Hoyerswerda	97
12	Erfurt	127	26	Görlitz	92
13	Dessau	126	27	Zwickau	90

Ranking of counties in Germany, sorted by QOL using implicit prices on land markets considering Tourism, Met.area, Peripheral, Rural, East, Rural x East, Poverty, Share of water, Share of forest, Leisure, Accessibility, Education, Crime, Industry emissions, Local labor market, Alternative job opportunities, and Sunshine.

Figure 1.2: Quality of Life in West Germany

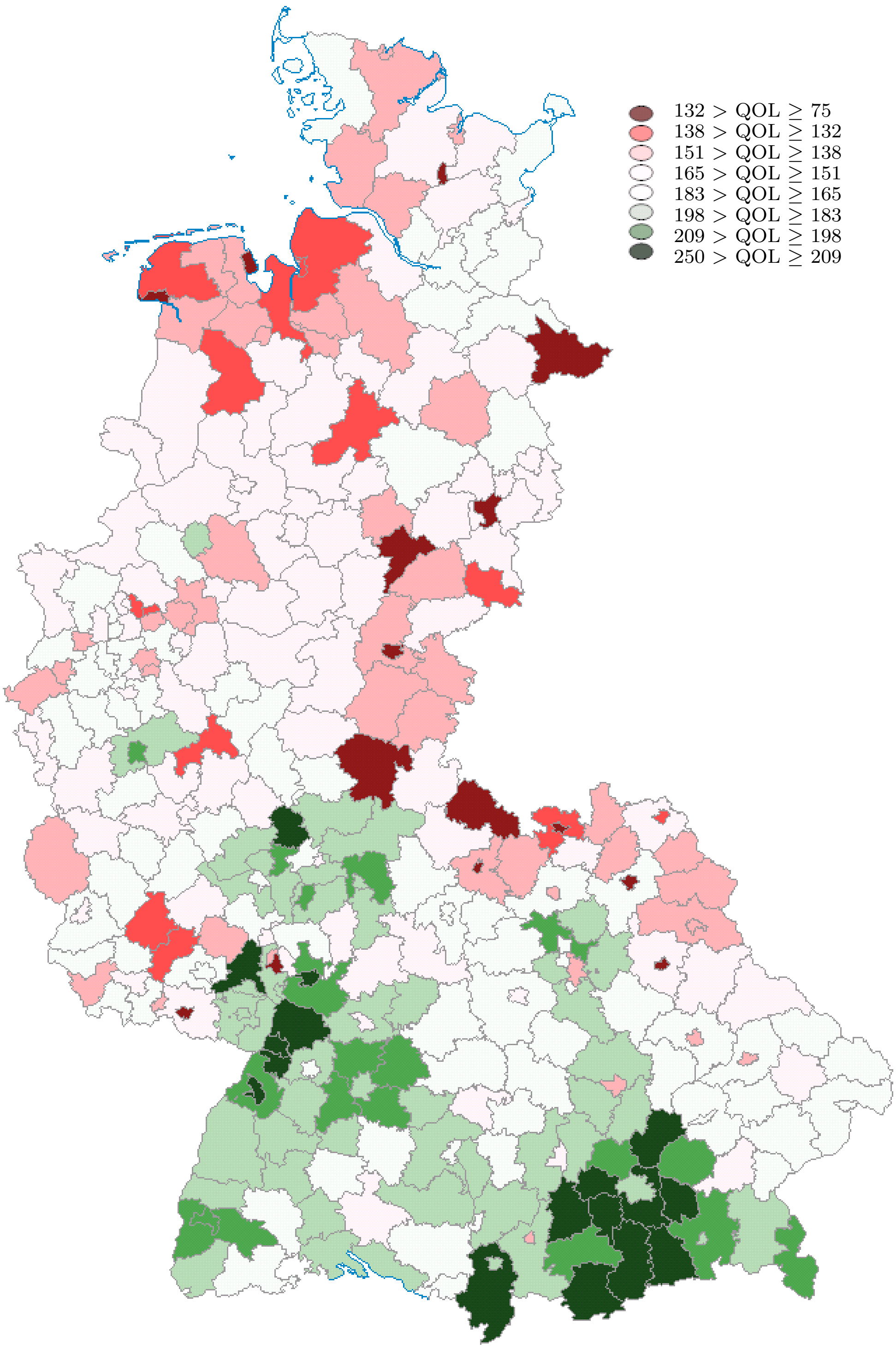
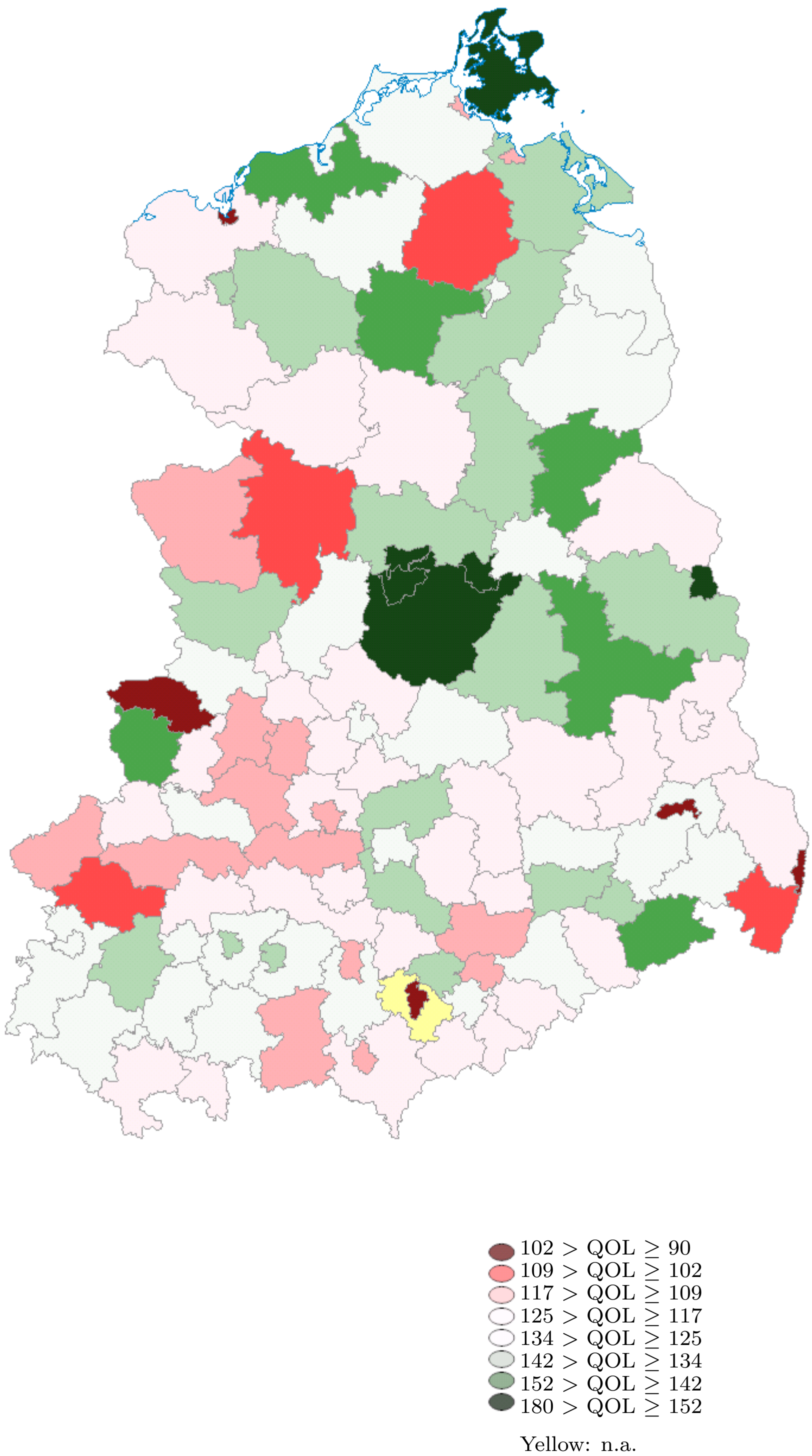


Figure 1.3: Quality of Life in East Germany



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Chapter 2

The Capitalization of Public Services and Amenities into Land Prices – Empirical Evidence from German Communities

Abstract

Applying the hedonic approach to land prices, this paper investigates the capitalization of public services and pure amenities in a cross section of German communities. Possible spill-over effects from neighboring municipalities are explicitly included in the analysis and prove to be of considerable importance. Estimates of the impacts of local attributes on land prices are obtained taking into account the spatial structure among unobserved variables. The results confirm that differences in land prices can largely be attributed to local conditions and policies. This implies a significant degree of mobility as well as a sizeable valuation of local attributes by German households.

2.1 Introduction

How much are people willing to pay to live in a sunny and secure community featuring a good public transport system, nice recreational facilities, and plenty of shopping opportunities? This question is an interesting one, especially for politics at the community level. After all, many of the determinants of the local quality of life are, at least to some extent, publicly produced goods. However, local governments face a trade-off when it comes to the provision of public services. On the one hand, these services have to be financed by probably unpopular measures. On the other hand, if public spending ensures a high quality of life, this may both help to win elections and to attract new citizens, thereby increasing the tax base. Moreover, in the case of Germany, the attraction of new residents directly generates revenues via the system of municipal fiscal equalization ("kommunaler Finanzausgleich").

For quite a long time, economic theory has a method to answer questions of the kind mentioned above. The hedonic analysis of heterogeneous commodities dates back to the early works of Waugh (1929), Court (1939), and Griliches (1961, 1971). In the context of this paper, however, the idea of the hedonic approach is to utilize differences in land prices across communities to infer the marginal willingness to pay for single community attributes including the quantity and quality of public services. Rosen (1979) and Roback (1982) were the first to apply the hedonic approach in a general equilibrium context, including the location decisions made by firms. Since then, the method has been widely applied and developed in the USA (see Blomquist 2006 for an overview).

Nevertheless, there is hardly any analysis of this kind for German communities. Büttner (2003) finds capitalization effects of a number of amenities and disamenities in a set of German communities. However, his research mainly focusses on capitalization of the land tax. Given the large fraction of the public sector's budget consumed by sub-national governments in Germany, an evaluation of locally provided public services surely makes sense. The case of East Germany thereby fits especially well for several reasons. On the one hand, after the reunification of Germany, the eastern part of the land has experienced a massive and continued outflow of people looking for work in West Germany. Many small and more remote places now face severe problems in maintaining their infrastructure while the bulk of young and productive people is leaving. Among the 505 municipalities of the Free State of Saxony, only 23 (including the cities of Dresden and Leipzig) show a positive population growth for the period from 2000 to 2006. A reliable evaluation of community characteristics that helps to change this trend and attract new residents should therefore be vital for most East German municipalities. On the other hand, precisely through the considerable degree of mobility that has been shown by the citizens of eastern Germany, it qualifies for hedonic analysis of this kind. After all, household mobility is a crucial assumption if the capitalization of public services or amenities is to be observed.

In order to investigate the capitalization of public services and amenities into land prices in German communities, I focus on the 505 municipalities of the Free State of Saxony, using data from a variety of sources. Due to a lack of reliable data on wages at the community level, the analysis is constrained to compensatory differentials on the market for real estate and does not consider the full general equilibrium model proposed by Roback (1982). Given the rather small dimension of communities, the possibility of spill-over effects of local characteristics must be considered. Residents of neighboring municipalities are likely to enjoy not only the amenities provided in their home community, but also those in the surrounding municipalities. The empirical analysis explicitly allows for such spill-over effects by including spatial lags of the variables capturing public services and amenities. Moreover, possible spatial dependence in the unobservables is taken into account to ensure correct statistical inference.

The results show that most public services included in the analysis do significantly capitalize into land prices, with the quality of public transport systems and the share of land dedicated to recreational purposes receiving the highest valuation by Saxony's citizens. The local crime rate seems to matter for households of higher income only, as a significant capitalization effect is found for land prices at sites of high quality exclusively. The conjecture that local characteristics also affect the land prices in neighboring communities is confirmed as most spatially lagged indicators prove to be significant. Thereby, up to 70% of the variation in the value of land across communities can be explained by the used set of variables. These findings imply that household mobility in the state of Saxony is high enough to create capitalization effects. The hedonic approach is therefore a promising tool in the evaluation of the local provision of public services and can help communities to develop well defined strategies to regain some of their lost population.

The remainder of the paper proceeds as follows. The next section briefly illustrates the theory behind hedonic prices. Section 3 discusses the investigation approach and section 4 describes the data. Section 5 presents the results from the land-price regressions. Section 6 is concerned with the illustration of the resulting hedonic prices. Section 7 provides a short summary.

2.2 Theoretical Background

This section provides a short overview of the hedonic analysis of the housing market. The presentation largely follows that of Sheppard (1999). In contrast to many simple consumption goods that show relatively little variation in composition as well as in prices, the good *housing* is much more heterogenous. Consumers on the housing market can choose between units differing in age, size, the number of bedrooms, etc. Moreover, since residences are inextricably linked to their location, regional conditions as well as regional public services become quasi attributes of a dwelling. Each unit of housing in community j, h_j, can therefore be viewed as a bundle of many characteristics, $a_{i,j}$, which are demanded by consumers but cannot be purchased on their own. Apart from these attributes, consumers derive utility from the consumption of a composite good, x_j, and receive an exogenous income, y. Preferences are thus given by the quasi-concave utility function

$$u = u(x_j, a_{i,j}). \tag{2.1}$$

Assuming that mobility between locations is costless, spatial equilibrium requires that residents' utility is equated across all regions, leading to the familiar no-arbitrage condition

$$u^* = V\left(\underbrace{y - R}_{x_j}, a_{i,j}\right), \tag{2.2}$$

where $V(.)$ denotes the usual indirect utility function. $R(u, y, a_{i,j})$ represents the bid-rent function that is defined as the maximum price a consumer is willing to pay for a unit of housing with attributes $a_{i,j}$, given her income and utility level. Let the price of one unit of housing, $r_j(a_{i,j})$, be a function of the attributes of the respective dwelling. Then, maximization of (2.1) subject to the budget constraint, $y \geq r_j(a_{i,j}) + x_j$, together with implicit differentiation of (2.2) yields the following equality for the hedonic price of attribute i:

$$f_i = \frac{\partial r_j}{\partial a_{i,j}} = \frac{\partial R}{\partial a_{i,j}}. \tag{2.3}$$

Thus, the hedonic price f_i of any attribute a_i is defined as the marginal contribution of attribute a_i to the price of one unit of housing. Furthermore, in this simple setting, an estimate of the hedonic price allows direct inference of the consumers' marginal willingness to pay for the respective attribute.

2.3 Empirical Approach

To obtain empirical estimates of the capitalization of local amenities and policies into land prices, I estimate hedonic land-price regressions. In a first step, I regress the natural logarithm of the community land price on a set of (dis-)amenities and local public services:

$$\ln r_j = \alpha_0 + \alpha_1 z_j + \alpha_2 A_j + \varepsilon_j, \tag{2.4}$$

where z_j is a vector of characteristics of the market for real estate and A_j is the set of (dis-)amenities and public services in community j. Note, that there is no a-priori classification of the community characteristics as an amenity or disamenity at this point. However, when interpreting the results the nature of most of our variables is common sense. The vector z_j contains a couple of control variables in order to capture variations in the location rent as suggested by standard models of the urban land market (see DiPasquale and Wheaton, 1996). This includes population density as the main determinant of the location rent within metropolitan and urban areas and population growth as an indicator of the expected change in the location rent. Moreover, indicators of the relative land use and the distribution of residences within buildings are included here.

The issue treated in this study is of an intrinsically spatial nature. There are at least two points to take into account in estimating such relationships. First, communities are rather small spatial entities such that it is perfectly reasonable to expect spill-over effects of (possibly publicly produced) amenities between neighboring communities. Publicly provided parks are a good example of goods that enhance the quality of life of all people within a certain distance regardless of their residential community. To capture such effects, spatial lags of most community characteristics are constructed. Formally, a_{-j} denotes the spatial lag of variable a_j and is transformed according to

$$a_{-j} = \sum_k W[j,k]a_k, \tag{2.5}$$

where W is a spatial weighting matrix containing inverse distances[1] as weights with:

$W[j,k] = 0$ if distance between k and $j > 30$km,

$W[j,k] > 0$ if distance between k and $j \leq 30$km, and

$W[j,j] = 0$.

In other words, the spatially lagged counterpart of the local crime rate in municipality j contains the inverse-distance-weighted sum of crime rates in all surrounding communities within a radius of 30 km.[2] Note, that by taking the sum of values in the surroundings explicit emphasis is put on the question of how central a community is located. This form of aggregation pays attention to the fact that municipalities surrounded by many other, possibly attractive, communities exhibit a greater quality of life to most people than remote

[1]Distances are own calculations based on UTM coordinates (zone 33, WGS84 ellipsoid) of the Federal Bureau of Cartography and Geodesy ("Bundesamt für Kartographie und Geodäsie").

[2]Although chosen arbitrarily, the mark of 30 km seems a reasonable guess when thinking of cross-border effects of community characteristics. However, regressions with varying cut-off values between 15 and 90 km have been carried out and the results proved very robust against such variations.

places do. On the contrary, a row standardization would ignore this argument by assigning more equal weights to each location.

Another important point to be addressed in this spatial context is the likely presence of dependence in the unobserved variables. The literature on spatial econometrics emphasizes that inference based on simple OLS estimates might be incorrect if individuals are not independently distributed over space.[3] Therefore, I follow Conley (1999) and estimate a heteroscedasticity and spatial-dependence consistent covariance matrix of the orthogonality conditions. Thus, the second set of regressions carried out in this study can be formalized as:

$$\ln r_j = \beta_0 + \beta_1 z_j + \beta_2 A_j + \beta_3 A_{-j} + \epsilon_j, \qquad (2.6)$$

where A_{-j} denotes the vector of spatially lagged (dis-)amenities and ϵ_j are the spatial dependence robust error terms.

In a next step, the coefficients (β_2, β_3) are converted into implicit prices for the amenities and public services. In this case, these implicit prices are just the marginal effects obtained in the regression analysis and are given in € per sqm at the moment of purchase. This representation avoids any additional sources of imprecision that might arise through a translation into monthly budget figures.

2.4 Data

This study is concerned with the 505 communities of the German federal state of Saxony. Table 2.1 presents summary statistics for land prices, amenities, public services and control variables. Most of the data refers to the year 2006 and is obtained from two sources, the

[3]See Anselin (2001) for an overview.

statistical office of Saxony and the Development Bank of Saxony (SAB). The latter provides a couple of interesting measures of public services at the community level; for example, the rate of physicians to patients as an indicator of the provision of health services. Another measure of health services is given by the dummy variable *Hospitals* which takes the value 1 if a hospital is located in the community itself or in an adjacent municipality. In order to capture traffic connections as well as remoteness, a weighted average of minutes of driving time to a number of common destinations such as place of work, school, shopping centers, train station, and airport is used. The SAB furthermore provides a self constructed measure of the quality of the public transport system. This figure basically relates the local number of daily driven kilometers in the public transport system to population density.[4] Moreover, the number of criminal offences against persons per 1,000 inhabitants is used as an indicator of the level of public security provided by a municipality. The degree of local provision with basic goods is captured by a variable representing the area occupied by food retail stores per inhabitant.

Another variable of interest is the local unemployment rate, which indicates the economic situation in the municipality as well as the individual labor market risk faced by residents. The figures are taken from the state's statistical office, and from the same source stem the variables reflecting the local structure of land use. Thereby, the percentage of land dedicated to recreational purposes is included as an amenity to households. The fractions of community area occupied by buildings or traffic, on the other hand capture features of the local market for real estate. By the same token the number of buildings containing 2, or 3 or more residences, respectively, are included in the analysis. Possible agglomeration effects that are not due to the considered characteristics are controlled for by including a dummy variable for cities with a population greater than 5,000 people and the population density itself. Furthermore, land prices are likely to be in part driven by expectations on

[4]The exact formula is: $PublicTransport = \frac{1}{100} \frac{Avg. daily number of driven kilometers}{\sqrt{min(settlementarea/totalarea; 5\%)}/\sqrt{inhabitants/settlementarea}}$.

Table 2.1: Descriptive Statistics

Variable	Definition	Obs.	Mean	Std.Dev.	Min	Max
Land price:						
Land price	€ per sqm	505	29.2	23.2	4.03	362
Land price *basic*	lots in sites of basic quality in € per sqm	390	17.3	11.9	4.4	115
Land price *medium*	lots in sites of medium quality in € per sqm	495	25.1	15.6	4.4	170
Land price *good*	lots in sites of good quality in € per sqm	351	36.5	29.9	4.4	250
Controls:						
Land: *buildings*	share of total area in %	505	6.56	4.84	1.58	33.3
Land: *traffic*	share of total area in %	505	3.91	1.61	1.34	11.9
Buildings w. 2 residences	share of total buildings in %	505	24.6	6.93	7.49	45.3
Buildings w. $\geq$ 3 residences	share of total buildings in %	505	16.5	11.1	.962	54.3
Distance to eastern border	in km	505	28.6	22.0	0	101
Density	no. of people per sqkm	505	202	228	18.8	1702
City	1 if population $>$ 5000	505	.317	.466	0	1
Populationgrowth	2000 - 2006	505	-.062	.038	-.229	.116
Population projection	share of people of age $>$ 65 in%	505	22.4	2.91	11.4	29.8
Unemployment	unemployed per inhabitant in %	501	8.26	1.78	4.25	14.7
Public Services and Amenities:						
Land: *recreation*	share of total area in %	505	.717	.961	0	11.3
Hospitals	1 if hospital in municipality or in neighboring mun.	505	.673	.470	0	1
Physicians	no. of physicians per ordinary patient	505	.649	.356	0	2.33
Crime	no. of criminal offenses per 1,000 inhabitants	505	4.71	2.41	.381	13.9
Peripherality	minutes of driving time to common destinations	505	20.0	7.13	1	48
Public Transport	avg. measure of frequency and vehicle capacity	505	.792	1.58	.082	27.1
Precipitation	annual average 1960 -1990 in l per sqm	505	713	114	486	1160
Commerce	food retail area per inhabitant in sqm per person	505	.299	.304	0	3.18
Spatial Lags:						
W Land: *recreation*	weighted sum of *Land: recreation* within 30 km	505	3.01	1.48	.637	8.18
W Physicians	weighted sum of *Phyicians* land within 30 km	505	2.74	1.05	.608	5.74
W Crime	weighted sum of *Crime* within 30 km	505	19.2	6.11	4.41	33.9
W Public Transport	weighted sum of *Public Transport* land within 30 km	505	302	106	68.5	764
W Commerce	weighted sum of *Commerce* within 30 km	505	1.27	.523	.266	2.94

Statistics for municipalities in Saxony, year 2006. Sources: Statistical Office of Saxony, Sächsische Aufbaubank (SAB), GSD Geographic Systems DataService AG, Deutscher Wetterdienst.

future developments. Therefore, population growth between 2000 and 2006, as well as the share of inhabitants older than 65 years enter the regressions as further control variables. The state of Saxony has frontiers with the Czech Republic and Poland. As both countries show substantial differences with respect to the economic and cultural background, the distance to the Eastern border is included to control for such structural variation within the Saxon municipalities. Finally, a pure amenity is considered by including figures on average precipitation in the communities. This variable captures long term averages from 1960 to 1990 and stems from the Federal Meteorological Office ("Deutscher Wetterdienst").

The dependent variable of the main regression is based on an official collection of purchasing prices for land.[5] The figures used are average values derived from purchasing prices for lots of nearly identical features and values. These so called standard ground values ("Bodenrichtwerte") refer to lots typical for the respective region and are reported separately for residential, commercial, and mixed areas. In order to take into account the fact that companies and households are both competing for land and to guarantee a maximum of representativeness, I calculate averages of these three categories using the corresponding shares of land as weights.[6] Moreover, the Development Bank of Saxony (SAB) provides similar data for purchasing prices for land, distinguishing sites of good, medium, and basic quality. This data is used to check the results of the main regression with respect to their robustness. Furthermore, income related patterns in the demand for local characteristics might be detected by separate analysis of the three categories, as better lots are likely to be demanded by households with higher income.

The spatial lags of the variables *Crime*, *Public Transport*, *Commerce*, *Land recreation*, and *Physicians* are calculated according to equation (2.5). Note, however, that such a spatial

[5] These prices are collected and stored by the Geschäftsstelle des Gutachterausschusses following §195 BauGB.

[6] Alternative regressions with the untransformed data showed that the results presented in this paper are robust to this transformation.

transformation does not make sense for all kinds of community characteristics. Take, for example, the unemployment rate. This indicator is not irreversibly linked to specific areas of land, since there exists the possibility of commuting. If a community features a splendid labor market this fact will not only be reflected in the local unemployment rate, but also in the unemployment rates of all neighboring municipalities. Including a spatial lag of the above mentioned form is therefore not very promising. In a similar manner, the precipitation in adjacent communities is most likely to be of minor interest to residents. In contrast, the variables *Hospitals* and *Peripherality* are not transformed because both of them already include a spatial reference to neighboring communities by definition.

2.5 Results

Table 2.2 reports the results of the hedonic regressions of land prices on the set of amenities. For reasons of comparison, the results for regression equation (2.4) which ignores any spatial issues are reported in Column 1. Columns 2 – 5 report the results of different specifications of equation (2.6) with spatial dependence robust standard errors and including spatial lags. The specifications differ with respect to the dependent variable. The results in column 2 are obtained using the local averages of all land prices. Therefore, this "main regression" gives the most representative picture and is later used to infer the hedonic prices (see next section). Columns 3 – 5 provide the respective results for the land prices in good, medium, and basic quality sites, which are based on fewer observations. First note that the explanatory power of the regressions in general is considerably high. The main estimation presented in column 2 is able to explain 66% of the variation in local land values, and for sites of medium quality this figure even reaches 70%. As the figures used as dependent variables are not directly observed market prices, the high goodness of fit is an important indicator for the validity of the presented results.

Table 2.2: Estimation Results

Variable	log Landvalue		log Landvalue		log Landvalue *good*		log Landvalue *medium*		log Landvalue *basic*	
log Share of land: *buildings*	-.426***	(.077)	-.463***	(.070)	-.255**	(.108)	-.183**	(.071)	-.168*	(.093)
log Share of land: *traffic*	.022	(.087)	.073	(.087)	.106	(.093)	-.045	(.070)	.112	(.092)
Share of buildings w. 2 residences	.017***	(.003)	.010***	(.003)	.009*	(.005)	.009***	(.003)	.008**	(.004)
Share of buildings w. $\geq$ 3 residences	.022***	(.003)	.011***	(.003)	.017***	(.004)	.013***	(.003)	.010**	(.004)
Distance to eastern border	.003***	(.001)	.004***	(.001)	.004***	(.001)	.006***	(.001)	.005***	(.001)
log Density	.356***	(.064)	.373***	(.062)	.195**	(.088)	.199***	(.057)	.156**	(.077)
City	.118***	(.042)	.083**	(.038)	.234***	(.065)	.113***	(.037)	.041	(.052)
Populationgrowth	1.45***	(.542)	.807	(.496)	.918	(.697)	1.00**	(.479)	.238	(.623)
Population projection	-.030***	(.007)	-.018**	(.007)	.005	(.009)	-.009	(.007)	-.011	(.008)
Unemployment	-.060***	(.013)	-.033**	(.013)	-.036**	(.015)	-.041***	(.011)	-.049***	(.014)
Public Services and Amenities										
log Share of land: *recreation*	.076***	(.027)	.060**	(.025)	.082**	(.038)	.091***	(.026)	.115***	(.037)
Hospitals	.107***	(.040)	.093**	(.036)	.152***	(.043)	.101***	(.031)	.060	(.039)
Physicians	.122*	(.062)	.169***	(.056)	.174**	(.078)	.110**	(.048)	.072	(.060)
log Crime	-.060	(.043)	-.017	(.039)	-.086*	(.046)	-.019	(.032)	-.026	(.052)
log Peripherality	-.211***	(.054)	-.172***	(.052)	-.154*	(.087)	-.139**	(.058)	-.035	(.066)
Public Transport	.031***	(.007)	.045***	(.007)	.019*	(.010)	.020**	(.010)	.032*	(.017)
log Precipitation	-.652***	(.165)	-.701***	(.186)	-.821***	(.256)	-.378**	(.157)	-.419*	(.229)
Commerce	.001	(.055)	.033	(.048)	.005	(.052)	.087**	(.044)	.047	(.056)
Spatial Lags										
W Share of land *recreation*			.073**	(.029)	.088**	(.036)	.088***	(.024)	.157***	(.029)
W Physicians			.043	(.074)	-.133	(.097)	-.011	(.068)	.053	(.083)
W Crime			-.033***	(.007)	-.003	(.010)	-.035***	(.007)	-.045***	(.008)
W Public Transport			.001***	(.000)	.001***	(.000)	.001***	(.000)	.001***	(.000)
W Commerce			.094	(.128)	-.137	(.152)	.050	(.108)	.063	(.133)
N	500		500		346		490		385	
R^2	.608		.658		.676		.697		.623	

Column 1: OLS estimation, heteroskedasticity robust standard errors in parentheses. Column 2 - 5: OLS estimation, spatial dependence and heteroskedasticity robust standard errors in parentheses. * denotes significance at the 10% level (** at 5%, *** at 1% level).

The different specifications by and large give a consistent picture. The bulk of coefficients on the explanatory variables prove to be significant at standard levels and practically all of them show the expected signs. Moreover, the results of the different specifications turn out to be consistent with respect to their significance levels and signs. Despite the varying dependent variables and the different number of observations, even differences in the absolute values of the coefficients are of minor magnitude.

High shares of recreational area, nearby hospitals and a good system of public transport all prove to be positively correlated with the local price for land, both when measured in the community itself or in its surroundings. In contrast, high levels of unemployment and precipitation are associated with a lower value of land. These effects are of similar magnitude throughout the different specifications, with the results for unemployment and the spatial lag of the public transport system being remarkably robust. A good provision of health services through physicians at the local level is also found to have a positive impact on land prices. However, the ratio of physicians to patients in the surrounding communities does not show a significant coefficient. This might indicate that the local provision of health services is considered to be sufficient, especially since the availability of hospitals is accounted for separately. No significant effect is found for the supply of basic goods, neither when measured locally nor in the neighbor communities. The remoteness of a community clearly goes hand in hand with lower prices for land. This result holds throughout all specifications, although the amenities of neighboring locations and the respective distances are explicitly controlled for. The results obtained for the crime rate and its spatial lag show an interesting variation across the quality levels of sites: The negative coefficient of the local crime rate is only significant in the specification referring to good locations. On the contrary, the crime rate in surrounding municipalities has a highly significant coefficient in all other specifications. Given that living space in sites of good quality is predominantly demanded by high income households, this might indicate that public security matters systematically more to people with higher income levels. The significance of the crime rate in the neighborhood might be explained by studies finding that criminal acts tend to be committed in adjacent locations providing more profitable opportunities, rather than in the residential region of the criminal (see, e. g. Katzmann 1981, or Büttner and Spengler 2008). However, without information on the origin of offenders, this cannot be confirmed.

Note that the results of all specifications clearly point at the existence of agglomeration effects. The coefficients on the natural logarithm of the population density, on the indicator for cities over 5,000 inhabitants, and on the share of buildings containing more than 3 residences are all significantly positive throughout the different specifications. However, the variables designed to control for expectations and speculation in the market, *i. e.* population growth and the share of old people, do not show consistently significant coefficients. A further interesting finding is the robust significant effect of the distance to the eastern border. Apparently, the proximity to the countries of the eastern enlargement of the EU is valued negatively at Saxony's market for land.

2.6 Hedonic Prices

The hedonic prices of public services and amenities are obtained according to equation (2.3) and are based on the results of the main regression shown in column 2 of table 2.2. Table 2.3 reports the resulting hedonic prices for the community characteristics. The figures in column 1 report the marginal willingness to pay for one unit of the respective amenity or public service in € per sqm at the moment of purchase. For example, the results suggest that households are willing to pay around € 0.96 per sqm to have a one percentage point smaller unemployment rate in their home community. Since each amenity is measured in different units, this exact form of representing the willingness to pay is not very convenient for getting a feeling of relative magnitudes. Thus, for ease of comparison, column 2

Table 2.3: Hedonic Prices (in €/sqm)

Variable	Price per unit	Price per 1 Std. Dev.
Unemployment	-.964	-1.72
Share of land: *recreation*	2.45	2.35
Hospitals	2.72	1.28
Physicians	4.94	1.76
Crime	-.105	-.254
Peripherality	-.251	-1.79
Public Transport	1.31	2.08
Precipitation	-.029	-3.26
Commerce	.964	.293
W Share of land *recreation*	2.13	.653
W Physicians	1.26	.186
W Crime	-.964	-.872
W Public Transport	.029	.493
W Commerce	2.75	.271

reports the prices in € per sqm for an increase of one standard deviation of the respective characteristic. Accordingly, a one standard-deviation increase in the unemployment rate is associated with a decrease in willingness to pay for one sqm of land of about € 1.72. By combining hedonic prices with the observed variation in amenities, this column gives an insight into what is mainly driving the differences in local land prices. Apparently, the share of recreational land and the quality of the public transport system play the biggest role in location choices of people, as they are valued at € 2.35 and € 2.08, respectively. Relatively high valuations are also found for physicians, the unemployment rate and good traffic connections, for which the hedonic prices lie around € 1.75 sqm for a one standard deviation enhancement. The prices for the crime rate and food retailing are of minor magnitude and are based on insignificant coefficients. Surprisingly, the only "true" amenity in the analysis, precipitation, is very highly valued by Saxony's inhabitants and has a price of € 3.26 per sqm for a reduction of one standard deviation. However, this high valuation might be a result of the severe flooding that took place in Saxony in 2002.

A somewhat puzzling finding is that the price of unemployment is not among the highest ones in this list. This is clearly at odds with the prevailing view that labor market conditions are the main determinant of inner German migration flows.[7] However, one possible explanation for this might be the overall alarming state of the East German labor market. Given the fact that huge numbers of East German workers are commuting to the western part of the land, the local rate of unemployment might not be of major importance, especially not when compared to the east German neighbors. Moreover, the community level is likely to be a too small entity of aggregation to measure the willingness to pay for labor market conditions. Labor markets are usually defined as broader regions, even when ignoring the possibility to find work in West Germany.

Care must be taken when looking at the figures regarding the spatial lags in Table 2.3. The numbers in column 1 report the implicit prices calculated for the spatially lagged variables as described in equation (2.5). In other words, each of these valuations refers to the weighted sum of the respective characteristic within the neighborhood. Thus, a reduction of the aggregated and inverse-distance weighted crime rates in the neighboring communities of 1 crime per 1,000 inhabitants is valued at € 0.96 per sqm. On the contrary, the prices reported in column 2 are calculated for a one standard-deviation increase of the respective characteristic in the closest community. The observations of the amenities in the closest neighbor are, however, still weighted with the inverse distance of this community. This representation relates the valuations to amenity levels within only one municipality

[7] This view is, among others, confirmed by a similar study for Germany at the county level by Büttner and Ebertz (2008) who find that among a range of local characteristics the willingness to pay is highest for good local labor market conditions. Moreover, the "Perspektive Deutschland" study 2004, a survey among more than 500,000 German households, also finds that, along with personal relationships, the labor market is the main reason for moving in Germany.

instead of a sum of community characteristics and should facilitate comparisons. Accordingly, the willingness to pay for a decrease of one standard deviation in the crime rate of the closest neighbor is € 0.87 per sqm. This is the highest valuation among the conditions in neighboring municipalities. High valuations are also associated with the share of land dedicated to recreational purposes (€ 0.65 per sqm) and the public transport system (€ 0.49 per sqm). Note, that all the neighbors' values are lower than their counterparts, which is a natural consequence of the lower influence on the local quality of life, that is reflected in the inverse distance weights.

2.7 Summary

In order to estimate hedonic prices for a number of public services and amenities, I apply the hedonic approach to land prices in the 505 communities of the Free State of Saxony. Taking into account spill-over effects from neighboring municipalities as well as issues of spatial dependence, the capitalization of community attributes into land prices is investigated.

The hedonic regressions of land prices on a set of community characteristics are able to explain up to 70% of the variation in land prices across the communities of Saxony. Estimation shows that capitalization of most of the investigated amenities and disamenities occurs in the expected way. The results indicate that the valuation of Saxony's citizens is highest for a good public transport system and high percentages of land dedicated to recreational purposes. Furthermore, the local crime rate seems to matter only at sites of higher quality, which are expected to be demanded by high-income households. In addition, a significant influence of attributes of neighboring communities is found. Accordingly, the public transport system, recreational land, and the crime rate in the surrounding communities are found to have the highest hedonic prices among all spatially lagged attributes.

The results confirm the usefulness of the hedonic approach in the German context. As many of East Germany's communities suffer extensively from the loss of young and productive individuals, an evaluation of the strengths and weaknesses of communities with regard to the attraction of households might help to recover some of the lost population. More centrally located, small municipalities could use it to develop strategies to take advantage of the recent rise in attractiveness of the big cities of Dresden and Leipzig.

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Chapter 3

Spatial Implications of Minimum Wages

Abstract[*]

This paper addresses possible consequences of a minimum wage in a spatial context. An empirical analysis utilizing German data shows that a significant spatial wage structure exists and that, as a consequence, the share of workers earning wages below a minimum wage will be particularly high in rural counties even if we control for educational and occupational differences. A theoretical analysis discusses the implications for the spatial structure of the economy and shows that while the wages in the countryside will be affected positively, wages will decline in the city, where employment and population rise. Workers in the city will further suffer from an increase in housing costs. This supports concerns that urban poverty might increase as a result of the introduction of a minimum wage.

3.1 Introduction

For the policy maker minimum wages are an attractive policy tool. Minimum wages are apparently targeted at the heart of the poverty problem, the motivation to fight poverty earns public respect, and the direct costs involved seem low. In fact, the evidence suggests that minimum wages do have an impact on the wage distribution raising the earnings of those that are at the bottom of the wage distribution. Opponents argue that minimum wages also have important adverse effects on employment. Thus, a controversial debate about the adverse consequences of minimum wages on employment consumes a lot of space in an empirical literature that employs sophisticated micro-level datasets and advanced econometric techniques to show that minimum wages have or have not adverse effects on employment (e. g. see Card and Krueger 1994, Card and Krueger 2000, Neumark and Wascher 2000, and Brown 1999).

In this paper we argue that it is generally overlooked that wage increases and adverse

[*]This chapter is based on joint work with Thiess Büttner. It is based on our paper "Spatial Implications of Minimum Wages," *Jahrbücher für Nationalökonomie und Statistik*, 229(2), 2009.

employment effects resulting from minimum wages are systematically different for different groups of workers. This is already indicated by the experience with minimum wages in Germany. While the minimum wage in the construction sector shows quite limited effects in the western part of the country it exerts rather strong adverse effects in the eastern part (e. g., Möller and König, 2008a). Moreover, given the wage differential between East and West, Ragnitz and Thum (2007) show that a federal minimum wage would mainly be binding in the eastern part of the country.

It is important to note that these asymmetries are built in, however, by the same striking simplicity of the concept that so much appeals to the policy maker: the minimum wage simply disregards all sorts of wage structures that may exist, including not only wage differences associated with skills, occupation, experience, and sex, but also differences with regard to industry, firm-size, and region. While the ignorance of these differences seems to be a necessary consequence of a social policy that is committed to combat poverty, all of these differences play a role in the economic consequences of minimum wages and, hence, are important for the effectiveness of minimum wages in reducing poverty.

An important dimension of the wage structure in this regard is the spatial wage structure that shows up in higher wages in urban agglomerations as compared to rural areas. This paper argues that if there is a uniform minimum wage imposed on cities and rural towns alike, we can expect that the minimum wage is much more restrictive in the countryside but might be rather ineffective for people working in the cities. Hence, the wages of workers that live in the cities might not benefit much from minimum wages. In fact, using the German example, we present some empirical evidence below showing that the share of workers earning wages below a minimum wage would be much higher in rural as compared to urban areas. While this difference might be explained by the different composition of the work force, we provide further evidence that the regional differences in the incidence of minimum wages are mainly driven by a spatial wage structure that is associated with differences in density even if we control for differences in education and occupation.

Based on these empirical findings we explore the consequences of an introduction of a uniform minimum wage in a stylized theoretical model that derives a spatial wage distribution in a migration equilibrium setting with productivity differences and housing costs. The analysis shows that imposing uniform minimum wages exerts distortive effects on the spatial structure of the economy. More specifically, we find that employment and population will rise in the more densely populated regions implying that wages of the working population in the cities might even fall. Moreover, the city population would also suffer from an increase in housing costs. This asymmetric impact is important since there is a close association between poverty and urbanization.[1] Thus, our findings support concerns that urban poverty might increase as a result of the introduction of a uniform minimum wage.

The paper is organized as follows. The first part is concerned with spatial differences in the extent to which the minimum wage is binding. Section 2 provides some basic empirical evidence about these spatial differences in the incidence of minimum wages in Germany. Section 3 provides some further evidence about the spatial wage structure that gives rise to these systematic differences. The second part of the paper provides a theoretical analysis of the consequences of these spatial differences in the incidence of minimum wages. Section 4 first lays out a stylized theoretical model that shows how a spatial wage distribution emerges in the migration equilibrium setting with productivity differences and housing costs. Subsequently, minimum wages are introduced and we discuss the consequences. Section 5 provides our conclusions.

[1] In the German case the poverty rate in the cities is almost twice as large as the poverty rate of rural counties: in 2004, the poverty rate in core cities has been 5.11% compared with a figure of rural counties of 2.89% (Source: German States' Statistical Offices).

3.2 Spatial Differences in the Incidence of Minimum Wages

There is an ongoing political debate in Germany about the economy-wide introduction of minimum wages. In 1997 a minimum wage of DM 16 (€ 8.18) for West Germany (DM 15.14 (€ 7.74) for East Germany) has been introduced in the construction sector (see König and Möller 2008b). Current political proposals for the uniform minimum wage by some of the unions and by the Social-Democratic Party point at levels of € 6.50 or even € 7.50. In the following, we investigate the spatial patterns of the incidence of an introduction of corresponding minimum wages for the case of Germany.

We make use of the regional sample of employees (*Beschäftigtenstichprobe*) of the Institute for Employment Research (IAB), which constitutes a two percent random sample of all German employees subject to social security contributions and provides figures on employment status, wages, and personal characteristics like age, education, and profession of the sampled individuals (for a detailed description of the data see Drews, 2008). Since the data refer to the place of work at the county level,[2] this dataset is well suited to provide evidence on the spatial structure of wages in Germany. For our purpose of illustrating possible spatial consequences of minimum wages we focus only on the latest year available, 2004. Furthermore, we include only full-time employed individuals aged between 16 and 62.[3]

[2]For reasons of privacy protection, some counties are aggregated into a region.

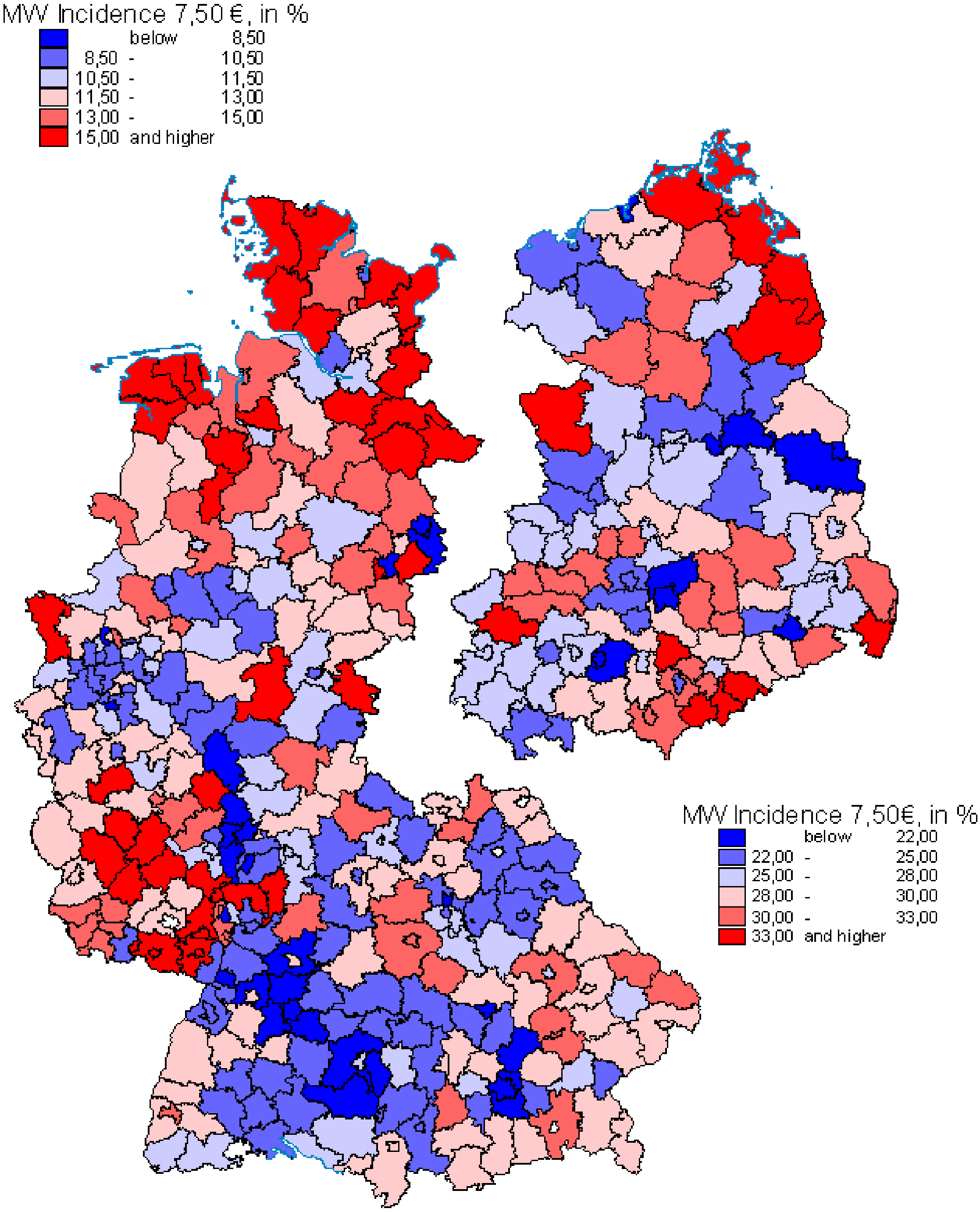
[3]Due to changes in individual employment status, employer, etc., for some of the sampled individuals several, possibly also simultaneous, spells are reported within one year, with the wage level possibly differing among different spells. In order not to overstate the incidence of a minimum wage in Germany, we include the highest respective wage reported for each individual worker in our analysis. To check for possible problems with simultaneous spells we conducted alternative analyses excluding all observations with a daily wage below € 40 to ensure that the results are not driven by such possibly defective observations. However, all results are unaffected qualitatively, and even quantitatively only minor changes were found.

Figure 3.1 illustrates the spatial differences in the minimum wage incidence, *i. e.* the average percentage of employees affected by a minimum wage at the level of counties and cities for West Germany and East Germany, respectively. Note that we include the top-coded observations when drawing percentiles from the wage distribution. As our data refer to daily wages but not to hourly wages and no information is provided about hours of work, we rely on a percentile of the wage distribution for full employed workers rather than directly applying a minimum wage. More specifically we rely on the analysis of Ragnitz and Thum (2007) who found that a minimum wage of € 6.50 (7.50) corresponds to the 8.50 (11.30) percentile of the wage distribution in West Germany and to the 18.10 (26.00) percentile in East Germany. Ragnitz and Thum are using microdata from the survey on the salary and wage structure in the manufacturing and service sectors that have been issued by Federal Statistical Office in 2007. While this data refers to 2001 our analysis focuses on 2004. Since the wage distribution might have changed over time, more recent data might result in different percentiles. However, our focus is not so much on the actual share of workers with wages below a minimum wage of € 6.50 or € 7.50. Rather we are interested in the spatial differences in the minimum wage incidence, regardless of the actual level.

A first inspection seems to confirm that some of the cities, like Hamburg, Berlin, Cologne, or Munich, are visibly less affected by a minimum wage of € 7.50 than their less densely populated neighbor regions. Further visualization of the spatial dimension of the minimum wage incidence is provided by Figure 3.2 which shows the average population density and the average percentage of employees affected by a minimum wage for five county types. The classification of county types is based on the typology given by the Federal Bureau of Regional Planning (*Bundesamt für Bauwesen und Raumordnung*).[4] Clearly, the share of

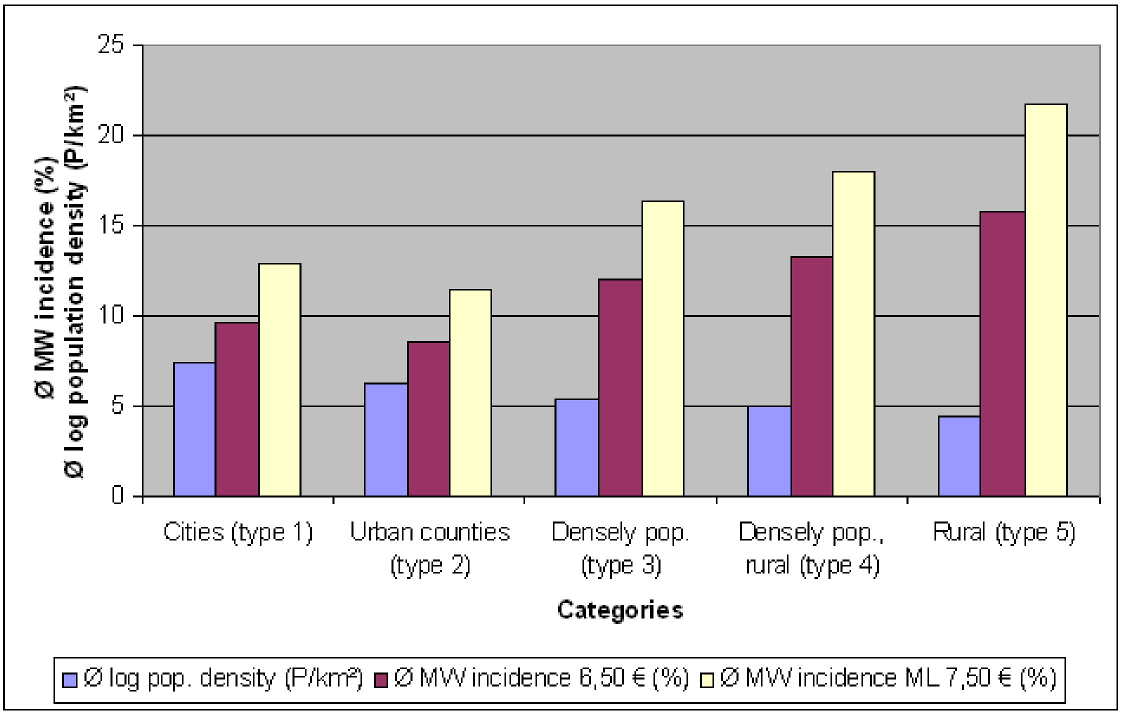
[4]We modify the existing classification such that counties are classified according to their own characteristics, ignoring the dimension of the general level of agglomeration of their surrounding area, that is contained in the original classification. More precisely, our county type 1 comprises cities with more than 100,000 inhabitants, county type 2 captures all counties with density above 300 inhabitants per sqkm. County type 3 refers to all counties with density above 150 but below 300 inhabitants per sqkm. County

Figure 3.1: Incidence of Minimum Wages



Percentage of employment spells with a wage below € 7.50 in East and West Germany.

Figure 3.2: Incidence of Minimum Wages by County Type



Percentage of employment spells affected by a minimum wage of € 6.50 (€ 7.50) and log of density by county type.

employees that earn less than the minimum wage is higher, the less densely populated the respective county is. The highest share is found for rural counties where more than 20% of employees would be subject to a minimum wage of € 7.50.

The visual impression is further underpinned by means of regression analysis, where we estimate the relationship between the local minimum wage incidence and the degree of

type 4 refers to all counties with density below 150 inhabitants per sqkm. County type 5 finally captures rural counties with density below 100 inhabitants per sqkm.

agglomeration. More precisely, the regressions take the form

$$MW_j = \beta_0 + \beta_1 Z_j + \varepsilon_j,$$

where MW_j denotes the percentage of employees affected by the respective minimum wage at location j, and Z_j is a vector of attributes reflecting the degree of agglomeration of region j.

Summary statistics of all variables employed in this study are reported in Table 3.1. Table 3.2 reports the results. The first set of regressions, reported in columns (1) and (2), confirms a highly significant negative relationship between the log of the population density and the percentage of workers affected by the minimum wage restriction. Doubling density would be associated with a decrease of the minimum wage incidence by about 1.68 (2.41) percentage points for the € 6.50 (€ 7.50) example. In our second set of regressions (columns (3) and (4)), we replace the density by dummy variables indicating the respective county type. The results clearly show that the minimum wage incidence is higher in less densely populated counties: the rural counties are having the highest coefficient indicating that the share of workers affected by a minimum wage is higher by about 6.19 (8.93) percentage points in rural counties as compared to cities.

Columns (5) and (6) provide results that include a dummy variable for counties in East Germany. It shows a strong positive effect confirming the results by Ragnitz and Thum (2007). Of course, since there is a clear difference in terms of population size and density between regions in East and West this dummy captures some part of the spatial variation in density. This explains why the inclusion of this dummy is associated with smaller density effects. However, the qualitative results prove robust. As compared to the cities the share of employees with wages below the minimum wage is up to 2.7 (3.9) percentage points higher in rural counties.

Table 3.1: Descriptive Statistics

Variable	Obs.	Mean	Std.Dev.	Min	Max
			Individual Data		
Daily wage	327130	83.1	33.7	1	167
Sex (is 1 for male)	353047	.641	.480	0	1
Age	353047	40.3	10.6	16	62
Edu.: No	353047	.131	.338	0	1
Edu.: Elementary school	353047	.687	.464	0	1
Edu.: High school	353047	.011	.103	0	1
Edu.: High school w. prof. training	353047	.053	.224	0	1
Edu.: College degree	353047	.045	.207	0	1
Edu.: University degree	353047	.074	.262	0	1
Prof. status: Simple Laborer	353047	.202	.402	0	1
Prof. status: Skilled	353047	.239	.427	0	1
Prof. status: Foreman	353047	.017	.128	0	1
Prof. status: Employee	353047	.543	.498	0	1
Prof. status: Home worker	353047	.000	.019	0	1
			Regional Data		
East	435	.257	.438	0	1
Population density	435	502.4	654.1	40.0	4010
MW incidence in %, € 6.50	435	12.1	6.62	4.08	56.1
MW incidence in %, € 7.50	435	16.4	8.61	5.08	61.3
Cty. type 1: Cities	435	.163	.370	0	1
Cty. type 2: Urban	435	.101	.302	0	1
Cty. type 3: Densely	435	.299	.458	0	1
Cty. type 4: Densely, rural	435	.340	.474	0	1
Cty. type 5: Rural	435	.097	.296	0	1

Sources: IAB Beschäftigtenstichprobe 2004, federal and regional statistical offices, and own calculations. All figures for 2004.

Table 3.2: Spatial Determinants of the Minimum Wage Incidence

Variable	MW incidence				MW incidence				MW incidence			
	€ 6.50		€ 7.50		€ 6.50		€ 7.50		€ 6.50		€ 7.50	
	(1)		(2)		(3)		(4)		(5)		(6)	
Constant	21.4⋆	(1.55)	29.9⋆	(2.00)	9.59⋆	(.459)	12.8⋆	(.639)	7.82⋆	(.245)	10.3⋆	(.323)
*log*Density	-1.68⋆	(.260)	-2.41⋆	(.335)								
Cty. type 2: Urban					-1.09	(.658)	-1.34	(.976)	.205	(.355)	.539	(.498)
Cty. type 3: Densely					2.42⋆	(.812)	3.56⋆	(1.05)	2.26⋆	(.608)	3.32⋆	(.686)
Cty. type 4: Densely, rural					3.74⋆	(.714)	5.18⋆	(.941)	1.76⋆	(.472)	2.30⋆	(.550)
Cty. type 5: Rural					6.19⋆	(1.12)	8.93⋆	(1.56)	2.71⋆	(.445)	3.89⋆	(.603)
East									10.5⋆	(.428)	15.2⋆	(.512)
N	435		435		435		435		435		435	
R^2	.074		.091		.095		.111		.535		.658	

Dependent variable: share of employment spells with wages below the minimum wage in %. OLS estimation, heteroskedasticity robust standard errors in parentheses. Omitted category: *County type 1: Cities.* ⋆ denotes significance at the 5% level.

3.3 The Spatial Wage Structure in Germany

The descriptive evidence provided so far has not touched upon the issue of what is driving the wage differences that are behind the spatial differences in the incidence of minimum wages. Yet this is important for the economic consequences of minimum wages. If higher wages are the result of a spatial structure in the wages, such that wages in densely populated areas are systematically higher, the imposition of the minimum wage might distort the spatial wage structure with consequences for the spatial allocation of production. If, however, higher wages in the cities simply arise from differences in the composition of the labor force in terms of skill and occupation, the economic consequences might be rather different. Therefore, this section further explores the sources of the observed spatial differences in the wages.

As is discussed in the regional and urban economics literature, differences in productivity give rise to differences in the intensity of land use which is most strikingly reflected in population density. As the largest density is generally observed in urban agglomerations, the discussion about the spatial wage structure is centered around the so-called urban wage premium, *i. e.* the notion that wages tend to be higher in densely populated areas, and, in particular, in the cities. While there is much discussion on the determinants of the urban wage premium, its existence is confirmed by many empirical studies (e. g., Glaeser and Mare, 2001, for Germany see Lehmer and Möller, 2007).

In order to obtain quantitative estimates of the spatial wage structure in Germany, we run regressions relating the log of individual daily earnings to different measures of agglomeration, thereby controlling for individual characteristics. These Mincer-type wage regressions take the form

$$\ln w_{k,j} = \alpha_0 + \alpha_1 X_{k,j} + \alpha_2 Z_j + \varepsilon_{k,j},$$

where $w_{k,j}$ denotes the wage of individual k in location j, $X_{k,j}$ is a vector of personal characteristics of this individual, and Z_j is a vector of regional attributes reflecting the degree of agglomeration of region j.[5]

While the dataset is quite rich, a problem with the data is that the wage figures are top coded at the upper social security threshold. We employ two different estimation strategies to deal with this problem. First, we estimate a tobit model. As is well known, the basic tobit model relies on rather strong assumptions and suffers from inconsistency under conditions of heteroskedasticity. However, with increasing age the individual wages might well display a larger variance, since the job experience and the employment record will be more different within groups of older workers. Similarly, workers with higher levels of education might display a larger variance in wages (e. g., Martinsa and Pereira, 2004). We, therefore, employ a heteroskedastic tobit-model where we associate differences in the conditional variance of wages with the age and education level of the individuals.

In a second approach we focus on the median of wages which is less affected by the top-coding of the wages. We adopt a two-step procedure to censored quantile regressions suggested by Chamberlain (1994) and applied to regional data by Büttner and Fitzenberger (2001). In a first step, we group the data by cells of workers with the same education and the same age, and where employment takes place in the same district. For each cell the median wage is determined. In a second step, all uncensored cell medians are regressed on cell characteristics such as the population density.

Table 3.3 reports the results of different specifications using the Tobit approach to the

[5]Note that this wage regression is concerned with the cross-section. As the dataset used is a panel dataset that provides information also about earlier years, one might control for all individual differences using panel data techniques. Since we are concerned with a cross-sectional issue, this would require to focus on workers that have moved between counties of different types. An analysis along these lines is, however, beyond the scope of the current paper.

Table 3.3: Urban Wage Premium: Tobit Regression Results

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sex	.283*(.006)	.293*(.005)	.289*(.005)	.483*(.007)	.478*(.005)	.475*(.006)	.450*(.006)
Age	.073*(.002)	.071*(.002)	.071*(.002)	.061*(.002)	.060*(.002)	.060*(.002)	.061*(.002)
Age squared	-.001*(.000)	-.001*(.000)	-.001*(.000)	-.001*(.000)	-.001*(.000)	-.001*(.000)	-.001*(.000)
Edu.: Elementary school				.118*(.009)	.131*(.010)	.133*(.010)	.164*(.007)
Edu.: High school				.143*(.033)	.122*(.032)	.133*(.032)	.149*(.031)
Edu.: High school w. pr. tr.				.414*(.021)	.402*(.021)	.409*(.020)	.435*(.020)
Edu.: College degree				.851*(.035)	.850*(.034)	.855*(.034)	.892*(.031)
Edu.: University degree				1.22*(.056)	1.20*(.053)	1.21*(.053)	1.25*(.052)
Prof. status: Skilled				.030*(.008)	.036*(.007)	.038*(.007)	.070*(.005)
Prof. status: Foreman				.429*(.013)	.426*(.013)	.427*(.013)	.421*(.013)
Prof. status: Employee				.464*(.013)	.444*(.010)	.449*(.011)	.439*(.011)
Prof. status: Home worker				-.474*(.082)	-.456*(.080)	-.467*(.080)	-.483*(.082)
*log*Density		.087*(.014)			.060*(.012)		
Cty. type 2: Urban			-.007 (.036)			.045 (.031)	.015 (.029)
Cty. type 3: Densely			-.148*(.033)			-.079*(.028)	-.070* (.024)
Cty. type 4: Densely, rural			-.229*(.033)			-.158*(.029)	-.092* (.022)
Cty. type 5: Rural			-.312*(.048)			-.232*(.047)	-.100* (.027)
East							-.334* (.011)
N	353047	353047	353047	353047	353047	353047	353047
Log pseudolikelihood	-388120.33	-383360.89	-383802.88	-353845.33	-351272.78	-350995.53	-344669.53

Dependent variable: *log* of daily wage. ML estimation, 327130 obs. uncensored, and 25917 obs. right-censored. Standard errors in parentheses are heteroskedasticity robust and clustered at the regional level. Omitted categories are: *Edu.: No*, *Prof. status: Simple Laborer*, and *County type 1: Cities*. * denotes significance at the 5% level.

mean wage.[6] In column (1), we report a very basic regression of the log of daily earnings, controlling only for gender and age structure. The inclusion of the log of population density in column (2) yields an increase in the goodness of fit and the significant coefficient confirms a positive relationship between wage level and agglomeration. To be precise, we find that doubling population density is associated with a 8.7 percentage increase in wages. In column (3) we replace the density variable by several dummy variables capturing the county type of the individual's working place. The results confirm a spatial structure and show that the wage in rural counties is lower by about 31.2 percent.

In columns (4) to (7) we include controls for education and occupation. All coefficients on individual attributes are statistically highly significant and show the expected signs, except for the indicator of high-school graduation that does not seem to provide much information once it is controlled for high-school graduates with further professional education. Column (5) includes the log of population density. With all other coefficients remaining remarkably constant, the density again shows a significant positive association with the wage level. Note, however, that the coefficient obtained after controlling for skill and occupation is slightly smaller, indicating that a part of the density effect is captured by the composition of the labor force. In column (6) we again replace the density by dummy variables for the county type. While the urban counties are statistically not distinguishable from the omitted category (cities), the other three indicators of county categories are each significantly and inversely associated with the wage level. Note that when ignoring cities, a category that is based on the administrative status and the population size, the size of coefficients decreases with the density, confirming a monotonous relationship between density and the level of earnings. For rural counties we find that wages tend to be lower by 23.2 percent.

As reported in column (7), when accounting for structural differences between eastern and western Germany by means of a dummy variable we get similar results. While the size of

[6] For reasons of comparison, we report the equivalent OLS estimates in Table A.1 in the appendix.

the effects are smaller, the qualitative results prove robust: for rural counties we still find that wages are lower on average by about 10 percent.

Table 3.4 provides results for the median wage among the cells of workers with the same education, age, and district. We obtain a number of 3,863 uncensored cells with an average cell size of about 88 observations. At least when considering specifications that include controls for skills and occupation (column (4) to (7)) the results with regard to density and county type are remarkably similar to the above Tobit results. The wage differential between cities and rural counties is estimated to be on average 20.5 or 11.8 percent depending on whether a dummy for the eastern part of Germany is included.

Having shown that not only the absolute wage distribution shows marked spatial differences but also the conditional wage distribution obtained after controlling for skills and occupation, let us come back to the question of the spatial incidence of the minimum wage. The significance of the density variable or the county types in a wage regression that includes controls for education and occupation, indicates that there is a spatial structure that is not simply driven by composition effects: the same worker tends to earn more if employed in a more urbanized region. As a consequence, the probability to earn a wage rate that is below the minimum wage will be significantly higher in rural regions. To get an impression of the empirical magnitudes involved, we can use our estimates to obtain a statistical analogue to the minimum wage incidence derived in Section 2 above.

Based on the results presented in column (6) of Table 3.3, assuming a log-normal wage distribution for a simple laborer without completed schooling and with mean age,[7] we obtain an estimate of the probability to earn a wage below a minimum wage of € 6.50 of 34%. According to column (6), the wage differential between a city and a rural county is about -.232 percent. Given this substantial rural-urban wage gap, in a rural county the

[7]The associated standard deviation of the log of the wages is estimated with $\sigma = .537$.

Table 3.4: Urban Wage Premium: Median Regression Results

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sex	.210*(.009)	.211*(.009)	.210*(.009)	.326*(.013)	.315*(.013)	.317*(.013)	.294* (.012)
Age	.285*(.014)	.279*(.014)	.280*(.014)	.132*(.015)	.125*(.015)	.125*(.015)	.084* (.014)
Age squared	-.004*(.000)	-.003*(.000)	-.003*(.000)	-.002*(.000)	-.001*(.000)	-.001*(.000)	-.001* (.000)
Edu.: Elementary school				.112*(.043)	.124*(.042)	.119*(.042)	.038 (.039)
Edu.: High school				.023 (.047)	.047 (.046)	.041 (.046)	.034 (.043)
Edu.: High school w. pr. tr.				.167*(.052)	.207*(.051)	.197*(.051)	.189* (.048)
Edu.: College degree				.311*(.051)	.353*(.050)	.340*(.050)	.325* (.047)
Edu.: University degree				.415*(.051)	.462*(.050)	.449*(.050)	.445* (.048)
Prof. status: Skilled				-.227*(.077)	-.191 (.075)	-.196 (.076)	.098 (.068)
Prof. status: Foreman				.036 (.175)	.076 (.171)	.088 (.175)	.245 (.144)
Prof. status: Employee				.330*(.071)	.285*(.070)	.300*(.070)	.378* (.065)
Prof. status: Home worker				-.126 (.561)	-.247 (.613)	-.199 (.604)	-.070 (.280)
*log*Density		.065*(.006)			.065*(.007)		
Cty. type 2: Urban			-.002 (.021)			.021 (.022)	-.015 (.016)
Cty. type 3: Densely			-.080*(.019)			-.067*(.021)	-.067* (.013)
Cty. type 4: Densely, rural			-.136*(.019)			-.129*(.021)	-.082* (.013)
Cty. type 5: Rural			-.220*(.039)			-.205*(.040)	-.118* (.023)
East							-.308* (.013)
N	3863	3863	3863	3863	3863	3863	3863
R^2	.286	.345	.310	.596	.623	.619	.694

Dependent variable: *log* of daily wage. OLS estimation, standard errors in parentheses are heteroskedasticity robust and clustered at the regional level. Omitted categories are: *Edu.: No*, *Prof. status: Simple Laborer*, and *County type 1: Cities*. * denotes significance at the 5% level.

probability for the same type of worker to earn a wage below the minimum wage of € 6.50 is estimated to be no less than 51%. Accordingly, the probability to earn a wage below the minimum wage is larger in a rural county by 17 percentage points for this unskilled type of worker. However, column (7) which includes a dummy for East Germany obtains a smaller urban-rural wage gap of about -.100. Doing the same calculation for this specification,[8] we find that the probability to earn a wage below the minimum wage is larger in a rural county by 7.2 percentage points.

While controlling for composition effects, these estimates point at even stronger differences in the minimum wage incidence between urban and rural counties. Thus, the inverse relationship between urbanization and minimum wage incidence is confirmed.

3.4 Minimum Wages in Spatial Equilibrium

In order to discuss the consequences of minimum wages in the presence of a spatial wage structure, we start with outlining a theoretical model of the spatial equilibrium without minimum wages. We, then, introduce a minimum wage into this setting, and, finally, discuss the associated welfare implications.

3.4.1 A Basic Model of the Spatial Equilibrium

Consider an economy with M regions, $i = 1, 2, ..., N$. Region i hosts n_i identical households. Each of these households supplies one unit of (homogenous) labor and, thus, the total labor supply in region i is equal to the population size n_i. All labor is employed by

[8] The associated standard deviation of the log of the wages is estimated with $\sigma = .528$.

local firms according to a production function $F_i(n_i)$, with $\frac{\partial F_i}{\partial n_i} > 0$ and $\frac{\partial^2 F_i}{\partial n_i^2} < 0$. Note that the production function is indexed with i in order to allow for possible differences in productivity. Denoting the wage rate in region i with w_i optimal employment obeys

$$F_{in}(n_i) = w_i.$$

To derive labor supply in spatial equilibrium, let us assume that the representative worker household in region i enjoys utility from the consumption of a private good in the amount of x_i and of housing space in the amount of q_i:

$$u_i = \tilde{u}(x_i, q_i).$$

To keep the analysis simple let us assume that each household consumes a fixed amount of housing $q_i = 1$ and we can simplify the utility function

$$u_i = \tilde{u}(x_i, 1) = u(x_i).$$

Each region hosts one city that serves as center of production and is the place of residence for the mobile population. Let us employ a standard monocentric city model (see Fujita, 1989). Production takes place in the central business district, which is surrounded by the residential district. Consider a household located at the urban fringe which is in distance b to the city center. This household has commuting costs of kb and direct housing costs corresponding to the opportunity cost of land ρ. Since differences in the direct cost of housing within the city would only capture differences in the commuting costs, we know that the total cost of housing, *i. e.* direct housing costs plus commuting costs, is equal within the city. However, the total cost of housing might vary across cities if the population size differs. To see this, note that we have the following equilibrium condition for the housing market:

$$n_i = \int_0^{b_i} T_i(\delta)\, d\delta,$$

where $T_i(\delta)$ captures the available housing space at distance δ from the city center. Hence, the distance from the urban fringe to the city center is an increasing function of the total population size $b_i = b(n_i)$ with some positive elasticity.[9] As a consequence, the total cost of housing in the city is

$$h_i \equiv h(n_i) = \rho + kb(n_i),$$

which is increasing in population size.

Note that a larger population size implies a larger city, and, hence, the higher total housing costs reflect a larger location rent in the city center. As the urban area in the region increases we can also say that density is increasing with population size.[10]

Under conditions of household mobility, utility is equalized across locations such that the level of consumption is the same

$$u(x_i) = u(x).$$

For simplicity, we abstract from other sources of income and assume that mobile households only earn income from labor. Thus, we assume that households derive income from supplying one unit of labor to local production at a competitively determined wage. Since, however, housing costs may differ between cities, we can derive a labor supply function indicating the number of people that are willing to work and live in the city at a specific wage rate:

$$w_i = x + h(n_i)$$

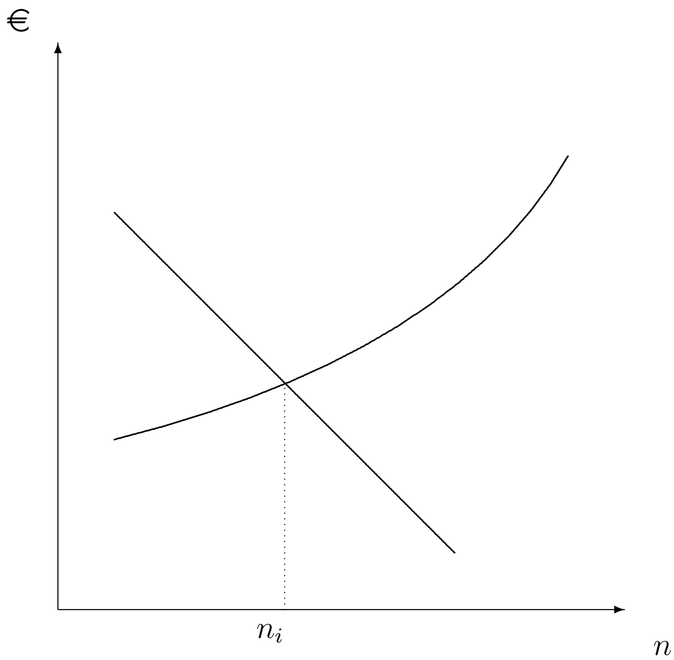
[9] A positive elasticity is obtained, for instance, in the simple case of a circular city with $T_i(\delta) = 2\pi\delta$. In this case the elasticity of b_i with respect to n_i is 0.5.

[10] Of course, a more elaborate model of the spatial structure would include investment in structures such that density even increases within the city.

Given the properties of the total housing cost function, note that the equilibrium wage rate is increasing in population size.

Labor market equilibrium in region i is graphically depicted in Figure 3.3. The labor supply

Figure 3.3: Labor Market Equilibrium in Region i



curve shows a positive slope that, as we have seen, results from the increase in the total housing costs. Note that the position of the labor supply curve depends on the level of consumption x_i. At higher levels of consumption and, thus, at higher levels of utility, the supply curve shifts upward. The labor demand curve, however, shows the usual negative slope. At the intersection point labor demand is consistent with the supply decision of the households and we obtain the equilibrium level of the corresponding wage rate and of employment which is equivalent to population in our model.

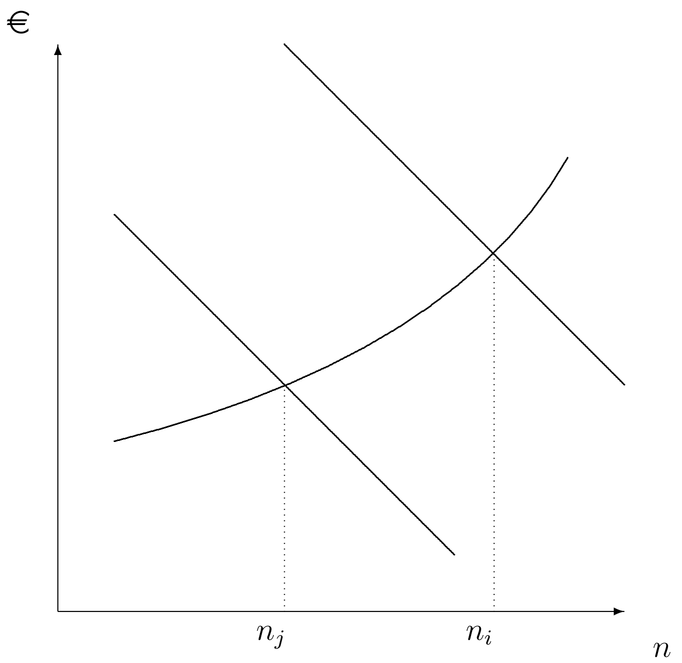
Suppose that total factor productivity is subject to region-specific productivity differences, and let us introduce a parameter γ_i that shifts productivity according to $F_i(n_i) = \gamma_i \tilde{F}(n_i)$. If $\gamma_i > \gamma_j$, region i has a higher productivity such that $F_{in} > F_{jn}$ at the same level of population. As a consequence, the population in i will be higher $(n_i > n_j)$. To see why, note that if population would be the same $(n_j = n_i)$ also housing costs would be equal. Hence, private consumption would have to be higher $x_i > x_j$. With more consumption x_i and the same housing costs, however, utility would be higher in i such that the migration equilibrium is disturbed. Hence, the population size in region i would have to be larger. The additional labor supply would result in a decline in the marginal productivity of labor and in higher total cost of housing until utility is equalized across regions. Since housing costs are increasing with population size, and since wages will compensate cost differences between regions, wages will differ in spatial equilibrium $w_i > w_j$.

Thus, we can state the following lemma:

Lemma 1 (City Size and Spatial Wage Structure)
In the migration equilibrium where utility is equal across regions, locations with higher productivity display a larger population size, a larger urban area, and higher wages.

Graphically, as displayed in Figure 3.4 an increase in productivity in region i relative to region j will result in a different labor demand curve that shows higher wages at the same level of employment. Since in the spatial equilibrium utility and, thus, consumption is equalized across regions, both regions face the same supply curve. As a consequence, the high productivity region will be larger in terms of population and display a higher wage rate than the other.

Figure 3.4: Regional Productivity Differences with Labor Mobility

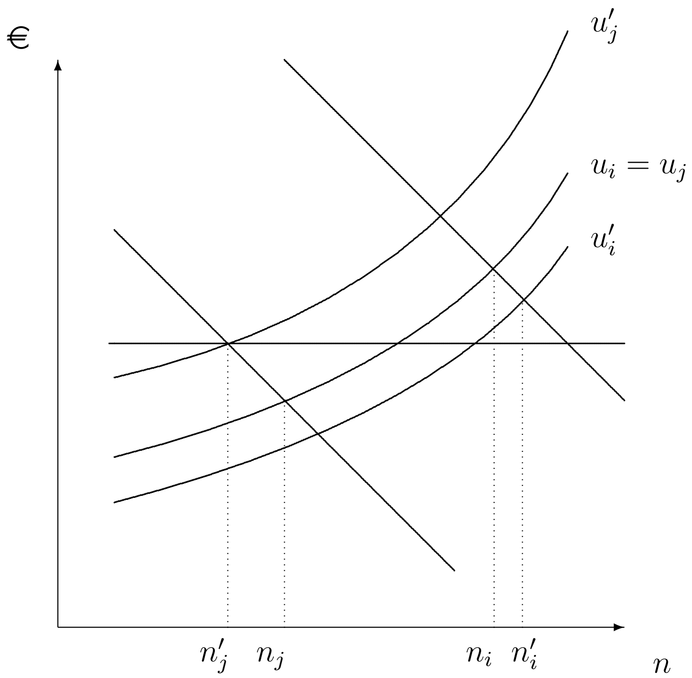


3.4.2 Introducing a Minimum Wage

Now let us consider an economy with several regions, which differ in productivity. Let us rank regions by size $n_1 > n_2 > .... > n_M$. Our analysis implies, so far, that the wage rate will differ in the sense that the region with the higher productivity displays a higher wage rate such that $w_1 > w_2 > .... > w_M$. Let us introduce a minimum wage $\overline{w}$ such that the wage rate of, say, region i is higher, whereas the wage rate in region $j = i+1$ is lower. To see how this affects the spatial distribution of activities, consider first the lower-productivity region where $\overline{w} > w_j$. We can see immediately, that for the marginal product of labor to rise, employment will have to decline. Without mobility we would obtain unemployment. With mobility, however, labor will move to more productive regions where the minimum wage is not binding and, hence, employment can be increased. As a consequence, both employment and population decline in the low productivity region.

The consequences of the introduction of a uniform minimum wage are illustrated in Figure 3.5. The initial equilibrium is characterized by levels of employment n_i and n_j and in both

Figure 3.5: Spatial Effects of the Minimum Wage



regions utility is at the same level.

With the introduction of the minimum wage, labor market equilibrium in region j requires a decline in employment to a level n'_j, and with higher wages and smaller housing costs there is an increase of utility in the low productivity region. The high productivity region experiences an increase in employment as well as a decline in wages as marginal productivity declines, and hence, utility decreases. However, migration cannot restore equilibrium since employment cannot be increased at the minimum wage in the low productivity region.

Also for the more general case with M regions we can establish the following proposition:

Proposition 1 (Agglomeration Effect of the Minimum Wage)
Imposing a minimum wage that is binding somewhere within the spatial wage distribution distorts the locational equilibrium such that the population of densely populated regions rises whereas the population of sparsely populated regions declines.

<u>Proof:</u> Given labor mobility the consumption level earned by workers in different regions is equalized. Taking account of the labor demand equation this implies

$$F_{in}\left(n_i\right) - h\left(n_i\right) = F_{jn}\left(n_j\right) - h\left(n_j\right).$$

Suppose that region j is less productive such that $n_j < n_i$. Imposing a minimum wage that is binding in region j but not in region i implies that

$$\overline{w} = F_{jn}\left(n'_j\right).$$

With this constraint the model is overdetermined and, hence, the population size of region j is no longer determined by the above spatial equilibrium. However, in all regions where the minimum wage is binding, labor productivity is forced to rise implying that labor demand declines. With the total population size given, employment and population size in the unconstrained regions will expand. ■

Further results can be obtained with regard to spatial price differences. First consider wages. Intuitively, the spatial wage distribution is compressed. To see this, recall that the minimum wage is more likely to bind in the low productivity regions that display lower wages. At the same time, however, the wage level in the more productive regions declines since employment is increased.

Proposition 2 (Spatial Wage Distribution Effect of the Minimum Wage)
Imposing a minimum wage that is binding somewhere within the spatial wage distribution tends to compress the spatial wage structure.

Proof: We know from Proposition 1, that all regions where the minimum wage is not binding face an employment increase. All regions where the minimum wage is binding experience a decline in employment. Hence, the marginal productivity is increasing in all regions where the wage rate is below the minimum wage, whereas it declines in all regions above the minimum wage. As a consequence, wages in the latter group decline, whereas wages in the former group increase. ■

With regard to housing costs a different result is obtained. Due to the agglomeration effect, we have a larger demand for space in the large regions that are unconstrained and a reduction of the demand for space in the smaller, constrained regions. Let us state this as our third proposition.

Proposition 3 (Location Rent Effect of the Minimum Wage)
Imposing a minimum wage that is binding somewhere within the spatial wage distribution tends to raise total housing costs and location rent in the more densely populated regions and to reduce total housing costs and location rent in the less densely populated regions.

Proof: We know from Proposition 1, that all regions where the minimum wage is not binding face an increase in population. All regions where the minimum wage is binding, experience a decline in population. Hence, the total housing costs are increasing in the first group but decreasing in the latter. ■

3.4.3 Welfare Implications

It is tempting to consider welfare implications. We have one group of workers that experience higher wages at lower housing costs. For this group utility rises. A second group of workers in the high productivity regions experience a utility decline since wages fall and housing costs rise. A third group of workers that leave region $j, ..., M$ and move to regions $1, ..., i$ also experience a decline in utility. In fact, since utility is equalized across regions in the initial equilibrium, and will still be equalized across regions $1, ..., i$ where wages are above the minimum wage, the decline in utility experienced by the second and third groups of workers will be the same. Can we say that the gain of the one group with an increase in utility outweigh the losses of the other two groups? In order to address this question it is useful to discuss the efficiency properties of the spatial equilibrium with and without minimum wages. A standard way to approach this issue is to invoke a central planner that aims at maximizing the utility of a representative worker household in jurisdiction i under the spatial equilibrium constraint that worker utility is equalized across jurisdictions.

$$
\begin{aligned}
\mathcal{L}^{cp} = u\left(x_i\right) + \sum_{j \neq i}^{M} \nu_j [u(x_j) - u(x_i)] \\
+\mu \sum_{j=1}^{M} \left[F_j - \left(x_j + h\left(n_j\right)\right) n_j\right] \\
+\varphi \left[N - \sum_{j=1}^{M} n_i\right].
\end{aligned}
$$

The first set of constraints require that worker utility is equalized across regions – they may be referred to as mobility constraints. The second set of constraints capture the budget constraints for the households requiring that the sum of a region's households' consumption and total housing costs is equal to the total income in this region. The last constraint simply states that the total population is fixed. The efficient spatial allocation of labor is obtained from the first order condition with regard to the population size.

$$\frac{\partial \mathcal{L}^{cp}}{\partial n_i} = \mu \left(F_{in} - x_i - h_i - h_{in} n_i \right) - \varphi = 0.$$

Taking account of the mobility constraints we derive the locational efficiency condition (Wildasin, 1986)

$$F_{in} \left(n_i \right) - h \left(n_i \right) - h_n \left(n_i \right) n_i = F_{jn} \left(n_j \right) - h \left(n_j \right) - h_n \left(n_j \right) n_j,$$

implying that a reallocation of labor cannot increase output net of housing costs.

Note that there is a discrepancy between the central planner's allocation and the above migration equilibrium even without the imposition of minimum wages. This is caused by the crowding effect that arises through the impact of population changes on the total housing costs. Intuitively, when moving from one region to the other the household ignores the crowding effect. Therefore, the *laissez faire* migration equilibrium turns out to be not efficient in our model. However, the imposition of the minimum wage does not improve this situation.

To see this, consider the crowding effect $h_n \left(n_i \right) n_i$ and note that it is positive and increasing in n_i. Hence, this term tends to be larger in the larger region. Compared with the basic spatial equilibrium, the marginal productivity in the larger region is too low – in the smaller region it is too high. Therefore, we know that the efficient allocation of labor and population would be such that employment and population are smaller in region i. Thus, denoting the efficient population size with a star we get

$$n_i > n_i^{\star} > n_j^{\star} > n_j.$$

However, with minimum wages, we know that we have an increase in agglomeration relative to the spatial equilibrium distribution, $\overline{n}_i > n_i$ and $\overline{n}_j < n_j$. Hence

$$\overline{n}_i > n_i > n_i^\star > n_j^\star > n_j > \overline{n}_j.$$

Thus, we can say that if there is an inefficient spatial equilibrium with excessive agglomeration, due to crowding effects, the imposition of minimum wages would give a further push towards excessive agglomeration.

Therefore, there is no possibility for a Pareto improvement, the group of workers that benefits from minimum wages cannot compensate the others.

3.5 Conclusions

In this paper we have discussed consequences of uniform minimum wages for the spatial structure of the economy. The starting point is the notion that a minimum wage is much more restrictive in the countryside but might be rather ineffective for people working in the cities.

An empirical analysis exploiting German data shows that a uniform minimum wage would affect the regional labor markets quite differently. In particular, we find that the share of workers that will be directly affected by the minimum wage is higher in rural counties as compared to cities and urban counties. While this supports concerns that the minimum wage is more effective in the rural as compared to urban areas, the economic consequences depend on the nature of the urban-rural wage differences. A further empirical analysis, however, shows that the wage differences are mainly associated with systematic spatial differences in the wages. Thus, the differences in the incidence of the minimum wage are driven by the spatial wage structure. According to our estimates, and based on some simplifying assumptions, for a simple laborer without completed schooling and with mean age the probability to earn a wage below the minimum wage is larger in a rural county by 17 percentage points as compared to a city or urban county.

To explore the consequences of the spatial differences in the incidence of minimum wages, we present a spatial equilibrium model of the labor market, where wage differences occur due to productivity differences and housing costs. Imposing uniform minimum wages in this setting exerts some distortive effects on the spatial structure of the economy. While the wages in the countryside will tend to rise, wages would decline in the city, where employment and population increase. Workers in cities will further suffer from an increase in housing costs. Thus, a federal minimum wage will tend to spur rural-urban migration and might raise rather than reduce urban poverty.

Having discussed the spatial implications of minimum wages in a rather straightforward model of the spatial equilibrium, let us briefly talk about possible limitations and extensions. A first issue is the possible existence of federal welfare programs. Such programmes would exert similar effects as minimum wages if they define a uniform reservation wage. Whether or not this is the case in Germany is not obvious, however. While the subsidies according to SGB II are, in fact, uniform, the large housing subsidy programme categorizes the cities and municipalities and assigns higher subsidies to households in urban agglomerations.

A second important issue is the role of wage bargaining. In Germany wage bargaining leads to sector-specific agreements defining wage floors that are uniform across several regions. This kind of agreements may exert similar effects on the spatial wage structure. However, wage bargaining is much less restrictive as it does not apply to all firms and shows some limited regional differences (Büttner, 1999). Nevertheless, our analysis suggests that these agreements might have already contributed to some excess agglomeration effect in

Germany.

Finally, we should note that the spatial wage structure is only one example of wage structures that are disregarded by a uniform minimum wage. With other types of systematic wage differences such as the firm-size wage distribution, similar problems will arise. Since a uniform minimum wage is more binding for smaller firms, it would distort the firm-size distribution, and in a competitive setting would benefit capital owners of larger firms, in the same way as the distortion of the spatial wage structure emphasized in this paper benefits land owners in cities.

Acknowledgements

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Table A.1: Urban Wage Premium: OLS Estimates

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sex	.383*(.009)	.389*(.008)	.386*(.009)	.543*(.009)	.535*(.006)	.533*(.007)	.506*(.007)
Age	.089*(.003)	.087*(.003)	.087*(.003)	.064*(.002)	.064*(.002)	.063*(.002)	.064*(.002)
Age squared	-.001*(.000)	-.001*(.000)	-.001*(.000)	-.001*(.000)	-.001*(.000)	-.001*(.000)	-.001*(.000)
Edu.: Elementary school				.070*(.009)	.085*(.008)	.088*(.008)	.121*(.006)
Edu.: High school				.133*(.029)	.108*(.027)	.120*(.027)	.141*(.027)
Edu.: High school w. pr. tr.				.349*(.018)	.339*(.017)	.345*(.016)	.376*(.015)
Edu.: College degree				.644*(.021)	.646*(.020)	.651*(.020)	.698*(.018)
Edu.: University degree				.875*(.026)	.862*(.024)	.873*(.023)	.924*(.024)
Prof. status: Skilled				.029*(.008)	.035*(.007)	.038*(.007)	.071*(.005)
Prof. status: Foreman				.407*(.013)	.404*(.013)	.405*(.012)	.402*(.012)
Prof. status: Employee				.526*(.015)	.500*(.011)	.506*(.012)	.498*(.011)
Prof. status: Home worker				-.456*(.071)	-.437*(.070)	-.444*(.069)	-.467*(.072)
*log*Density		.127*(.018)			.068*(.014)		
Cty. type 2: Urban			-.061 (.048)			.037 (.035)	.006 (.034)
Cty. type 3: Densely			-.252*(.043)			-.100*(.032)	-.089*(.028)
Cty. type 4: Densely, rural			-.350*(.042)			-.185*(.033)	-.112*(.026)
Cty. type 5: Rural			-.438*(.052)			-.259*(.047)	-.116*(.029)
East							-.339*(.014)
N	353047	353047	353047	353047	353047	353047	353047
R^2	.110	.149	.145	.355	.365	.366	.386

Dependent variable: *log* of daily wage. OLS estimation, standard errors in parentheses are heteroskedasticity robust and clustered at the regional level. Omitted categories are: *Edu.: No*, *Prof. status: Simple Laborer*, and *County type 1: Cities*. * denotes significance at the 5% level.

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Chapter 4

The Determinants of Joint Residential and Job Location Choices: A Mixed Logit Approach

Abstract

This paper empirically investigates the household's decision to reside and work either in the central metropolitan area, or in the surrounding nonmetropolitan area, or to commute between the two regions. As economic theory suggests, the location decision amounts to trading off wages, housing costs, and commuting time. A mixed logit model is employed to quantify the interaction effects of these economic factors in the joint residential and job location choice. The empirical approach does not rely on the restrictive IIA assumption and allows for arbitrary correlation patterns between coefficients. Using data from a recent survey of more than half a million German households, the elasticities of individual location choice with respect to wages, housing costs, and commuting time are estimated. The results show that individual valuations of these factors are of the expected signs but vary substantially in the population. Shifts in consumer surplus and in the spatial distribution of households that are associated with changes in the determinants of location choice are calculated based on the empirical estimates.

4.1 Introduction

The daily commute is an understood part of the job for the vast majority of people in the workforce. Strictly speaking, everybody who does not work at home is a commuter. The individual's decision on the extent of her daily commute is thereby inextricably linked to the decisions on where to live and where to work, respectively. Apparently, the non-separate choices on residence, job location, and the daily commute lead to a huge variety of outcomes in reality. The extent of commuting we can observe ranges from a three-minutes walk down the street to a three-hour trip. Commuting trips may take place within the community of residence or across the borders of communities, counties, federal states, or even countries. The magnitudes involved with commuting are thereby substantial in many dimensions. Following the most general definition of commuting, 85% of German employees considered themselves to be commuters in 2004.[1] The share of in-commuters among employees at the community of work was 37% in Germany in 2003.[2] Moreover, about 17% of commuters in Germany travel more than 25 km and five % more than 50 km one-way to their place of work.[3] The phenomenon is of course not restricted to Germany as the OECD statistics suggest: "Between one and 16% of the employed in OECD countries commute between regions every day."[4]

The typical picture one bears in mind when thinking about the issue is that people live in suburbs and commute to an urban center, where all the work is located at the central business district (CBD). This view of the "monocentric city" has been formally described and analyzed in the seminal works of Alonso (1964), Muth (1969), and Mills (1972). Although in reality production is of course not exclusively located at the city centers, Figure 4.1 illustrates that the assumption of monocentricity is a fairly good approximation of the structure of the labor markets constituted by many German cities. The map shows detailed commuting patterns in Germany. In numerous cases like Berlin, Hamburg, Munich, etc., there is a dominant center which attracts employees from a large surrounding area. All economic models in the Alonso-Muth-Mills tradition share certain basic insights, regardless of whether the production is located only at the city center or also at other points in space ("polycentric cities"). The individual location choice in this kind of models is determined by trade offs between wages, housing costs, and the economic cost of commuting. Besides these economic factors, the literature emphasizes the role of amenities and the local quality of life in the household's location choice.[5] Common to all these studies is the economic view that in equilibrium all the relevant factors balance out, such that utility is equal

[1]See Statistisches Bundesamt, 2005.

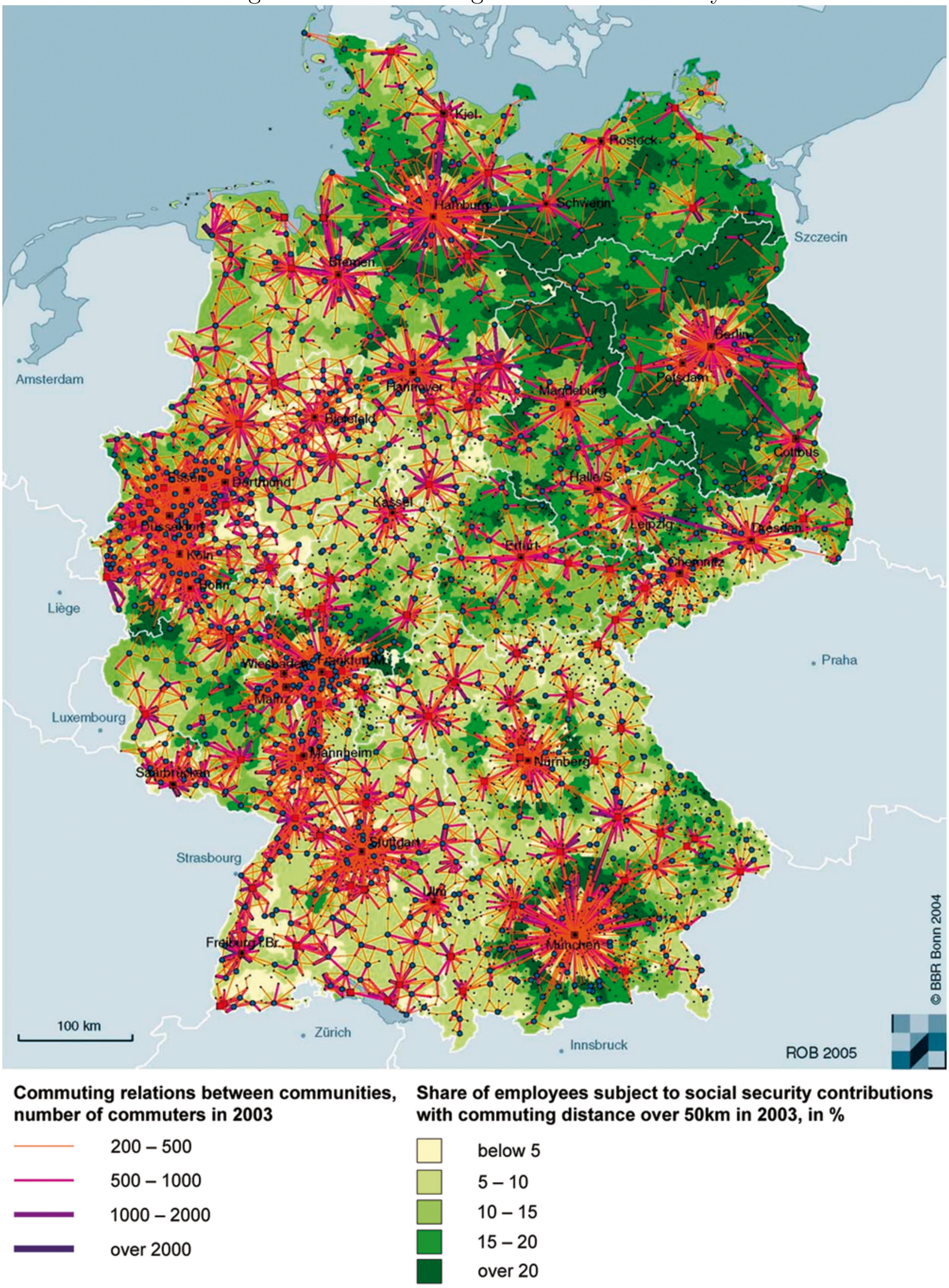
[2]Figures from the Federal Employment Office.

[3]See Statistisches Bundesamt, 2005.

[4]See OECD, 2005.

[5]The pioneering works being those of Rosen (1979) and Roback (1982); see Blomquist (2006) for recent developments.

Figure 4.1: Commuting Patterns in Germany



Source: BBR (2005)

across locations and/or choices.[6] Interestingly, the more recent new-economic-geography literature by and large ignores the phenomenon of commuting and consequently treats place of residence and place of production as the same (e. g. Krugman, 1991). There are, however, exceptions like the works of Krugman and Livas-Elizondo (1995), Tabuchi (1998), Murata and Thisse (2005), Tabuchi and Thisse (2005), and Borck et al. (2007). The just mentioned strand of literature appropriately emphasizes the role of industry location for the formation of commuting patterns. I will focus on the determinants of location decisions of individuals only, who arguably take the locations of possible employers as given.

According to economic theory, local wages, housing costs, and the cost of commuting represent the three most important economic determinants of the household's location decisions. The objective of this paper is to provide a comprehensive approach to empirically quantify the impacts of all three factors and their interactions in individual location choice. To theses ends, I exploit an extensive individual-level data set containing information on individual choices of residence and work location, commuting time, and individual characteristics. Augmenting these figures with county-level data on wages and housing costs, I estimate the underlying preferences that govern individual location choices. Discrete choice models have been widely used to analyze the determinants of the location choice of households. For example, Quigley (1985) or Nechyba and Strauss (1998) focus on the role of public services. Recent advances include Schmidheiny (2006) and Bayer et al. (2007), who are concerned with issues of sorting. Most of this literature looks at the choice of community, school district, or neighborhood. In contrast, the present analysis follows the idea of So et al. (2001) to focus on the relationship between the metropolitan area and its surrounding nonmetropolitan area. In their analysis, the choice set boils down to four alternatives: (1) To live and work in the CBD, (2) to live and work in the nonmetropolitan area, (3) to live in the nonmetropolitan area and work in the CBD, or (4) to live in the

[6] However, Frey and Stutzer (2008) cast serious doubts on this strong notion of equilibrium.

CBD and work in the nonmetropolitan area, respectively. The object of their study is the metropolitan area of Des Moines, Iowa, and the surrounding nonmetropolitan area. While adopting their modeling of the choice set, I apply it to a richer set of data which provides improved preconditions for the estimation. On the one hand, the data provides the relevant information on all labor market-regions in Germany instead of only one, allowing me to focus on the three largest cities, *i. e.* Berlin, Hamburg, and Munich. On the other hand, the households' counties of residence and work are identified in the data, such that regional figures can be assigned to the alternatives that have not been chosen. This means, in particular, that reliable information on the counterfactual outcomes of individual decisions is available.

For the purpose of estimation, I employ a mixed logit model where coefficients are allowed to vary randomly over decision makers, instead of being constant.[7] Train et al. (1987) and Ben-Akiva et al. (1993) are early works applying this method. Improvements in computer speed have led to an increasing use of such simulation based models of discrete choice, for instance in Bhat (1998) and Brownstone and Train (1999). This empirical model is particularly appropriate in the present context as it elegantly sidesteps some issues involved with classic multinomial logit estimation. Depending on the exact situation to be analyzed, individual location choice typically is at odds with the restrictive "independence of irrelevant alternatives" (IIA) assumption that is implicit in logit models. Most of the above mentioned studies make use of nested structures to address this problem.[8] The mixed logit model employed here does not rely on the IIA assumption. It further accommodates the hierarchical structure of location choice, given that three different labor market-regions are at scrutiny. More precisely, households are assumed to first choose a labor-market

[7]This approach is also known as "random coefficients logit" or "error components logit." See Train (2003) for an excellent introduction.

[8]A very illustrative example is Quigley (1985). He considers the household's location choice in three stages: Choice of dwelling given the choice of neighborhood and town, choice of neighborhood given choice of town and finally the choice of town.

region. Then, they decide on one of the four combinations of the location of job and residence in the (non)metropolitan area, given the choice of labor market. This is an analogous proceeding to the nested models mentioned before. Moreover, I allow for arbitrary correlation patterns in the estimation of coefficients. This approach explicitly addresses the problem that utility might be correlated over the four alternatives within each labor market, given the modeling of the choice set. The estimation results clearly confirm the predictions of economic theory with respect to the important roles of wages, housing costs, and commuting costs in the individual location decision. Moreover, the findings indicate a considerable degree of variation in the households' valuation of commuting- and housing costs. The estimation results are converted to elasticities to show how changes in wages, housing costs, or commuting time affect the distribution of households between metropolitan and nonmetropolitan areas. Accordingly, no systematic differences in the magnitude of the impacts between the three factors are found. Further results include the calculation of changes in consumer surplus induced by changes in the explanatory variables.

The remainder of the paper proceeds as follows. The next section briefly outlines the underlying economic theory. In section 4.3 the empirical setting and the data are described before the econometric specification is illustrated in detail. Section 4.4 presents the results from the mixed logit estimation, the implied elasticities, and results on consumer surplus. Section 4.5 discusses quantitative implications of the results on the basis of two hypothetical scenarios. Section 4.6 concludes.

4.2 Theory

In order to briefly illustrate the economic theory that underlies the empirical analysis, this section develops a simple model of household preferences and location choice.

4.2.1 Household Preferences

Regions are assumed to consist of a metropolitan area and a surrounding nonmetropolitan area. The political borders of the central area are the outcome of historical processes and are therefore considered as given. Each of the two areas i is characterized by a bundle of local attributes, A_i, and a competitive local housing market where the local price of housing, p_i, is determined. In addition, in each area a numeraire good, z, is produced with labor as the only input. Assume that z can be shipped costlessly within (and across) regions. Thus, each area hosts a local labor market, j, where the wage rate, w_j, is determined.

The preferences of households are described by a standard utility function

$$U(z, h, A),$$

where h is the consumption of housing. Households choose a residential location i, thus facing the local attributes A_i and the local cost of housing, p_i. They also choose a job location j, where the prevailing wage w_j is earned. If $i \neq j$, commuting costs of t_{ij} have to be incurred. Therefore, each household faces a budget constraint:

$$p_i h + z + t_{ij} \leq w_j. \tag{4.1}$$

Utility maximization subject to (4.1) yields the indirect utility function

$$U(z^*, h^*, A_i^*) := V\left(w_j, p_i, t_{ij}; A_i\right) \quad i, j = M, N, \tag{4.2}$$

where M and N refer to the metropolitan and the nonmetropolitan area, respectively. It directly follows that

$$\frac{\partial V}{\partial w} > 0, \frac{\partial V}{\partial p} < 0, \frac{\partial V}{\partial t} < 0. \tag{4.3}$$

These derivatives are the main determinants of the elasticities of the household's location choices that are to be estimated in section 4.4.

Local attributes may have a positive or a negative effect on utility, depending on their nature as an amenity or disamenity: $\frac{\partial V}{\partial A} \lesseqgtr 0$. This model does not include the descriptions of housing supply, the production side or the equilibrium concept. Such a full general equilibrium model is not required in the context of this paper as it focuses solely on the household's location decision.

4.2.2 Location Choice

Households simultaneously choose a residential and a job location to maximize utility. This requires that the chosen alternative is at least as good as all other possible alternatives:

$$V\left(w_{j^*}, p_{i^*}, t_{i^*j^*}; A_{i^*}\right) \geq V\left(w_j, p_i, t_{ij}; A_i\right) \quad \forall i \neq i^* \; j \neq j^*. \tag{4.4}$$

A close look at condition (4.4) reveals some interesting predictions of the model, as stated by So et al. (2001):

Prediction 1 *Households residing at i and working at j (commuters) demand higher wages than their non-commuting neighbors living at i and working at i.*

This follows directly from (4.3) and (4.4) as both types of households face the same housing cost and amenity endowment, but commuters incur higher commuting costs.

Prediction 2 *The wage gap between locations i and j is increasing in commuting costs t_{ij}.*

This is a straight forward extension of Prediction 1, since higher wages compensate households for higher commuting costs.

Assume that the price for housing at $i = M$ exceeds that at $i = N$[9] and that commuting costs are the same in both directions, *i. e.* $t_{ij} = t_{ji}$. Under this assumption, we have:

Prediction 3 *Average wages demanded in the metropolitan area will exceed average wages demanded in the nonmetropolitan area as long as the utility differences induced by different local amenity bundles do not offset the monetary utility differences induced by the cost of housing.*

To see this, consider two households residing at $i = M$ and $i = N$, respectively. Under the given assumption and without commuting, the household living at M will demand a higher wage, w_M for condition (4.4) to hold. For commuters from N to M the wage at M has to be higher than at N, following Prediction 1. By the same prediction, there is only one group that requires wages in the low housing-price location N to exceed those at M: Households who commute from M to N. Prediction 3 for average wages follows from this.

4.3 Empirical Approach

This section describes the empirical setup and the data used for the empirical analysis of the household's residential and job location choice specified in section 4.2. The estimated empirical model is derived in detail in subsection 4.3.2.

[9]This is most likely the case at the metropolitan area as prices are bid up due to higher population density.

4.3.1 Setting and Data

Given the focus on the relation between the metropolitan area and the surrounding nonmetropolitan area, individuals select one of four possible alternatives within their labor-market region to maximize utility:

MM: Live in the metropolitan area, work in the metropolitan area

MN: Live in the metropolitan area, work in the nonmetropolitan area

NN: Live in the nonmetropolitan area, work in the nonmetropolitan area

NM: Live in the nonmetropolitan area, work in the metropolitan area

It is assumed, that this choice is made given the prior choice of the labor-market region. The first choice is explicitly included in the empirical model, such that a nested structure with a total of 12 alternatives[10] obtains.

Objects of investigation are three labor market-regions ("Raumordnungsregionen") in Germany, which all exhibit an explicit center – periphery structure. In particular, the study focuses on the labor markets of the three largest German cities: Berlin, Hamburg, and Munich.[11] As Figure 4.2 illustrates, these regions consist of a central urban county (the metropolitan area) and various less densely populated surrounding counties that constitute the associated nonmetropolitan area.[12] Comparison of Figures 4.1 and 4.2 shows that

[10]First, the choice between the three labor-market regions, second the choice between the four alternatives MM, MN, NN, NM within the chosen labor-market region.

[11]See Appendix A for the exact listing of counties that constitute the respective (non)metropolitan areas.

[12]As Figure 4.1 shows, there are many more labor market-regions with a similar structure in Germany. I choose the largest three, because of the high number of observations. Unfortunately, the numerically demanding estimation procedure does not allow for the inclusion of more labor market-regions. However, simple multinomial logit estimations including all labor market-regions with a center–periphery structure yield qualitatively similar results.

the chosen administrative units correspond very well to the actual labor markets constituted by the three cities. Individual-level data on commuting time, location of residence and job, age, education, children, and household income are taken from the "Perspektive Deutschland" study 2004, a large survey among more than half a million Germans. It reports opinions and valuations of German residents concerning a variety of aspects of life in Germany and the German regions, respectively. Representativeness is ensured by sampling weights drawn from a parallel field-survey with more than 10,000 participants.[13] Monthly net household income in € is reported net of taxes and including transfers. I focus on full-time employed individuals only in order to ensure a certain degree of homogeneity of decision makers and of the driving forces behind their decisions. Since the analysis scrutinizes wages and commuting behavior, this is a sensible restriction of the sample.

Commuting cost is proxied for by commuting time. However, as individual commuting time is naturally reported for the chosen alternative only, the respective values for the other three alternatives are missing. This problem is solved by estimating commuting time for each of the four alternatives within one labor market region. In addition, this approach sidesteps any endogeneity issues that might arise because wages, commuting time, and housing cost are chosen simultaneously in the location decision. Individual commuting time (in minutes, one way) for each alternative a in each labor-market region k is therefore predicted by the linear equation:[14]

$$t_{n,a_k} = \lambda_0 + \lambda_1 age_{n,a_k} + \lambda_2 edu_{n,a_k} + \lambda_3 sex_{n,a_k} + \lambda_4 married_{n,a_k} + \lambda_5 kids_{n,a_k} + e_{n,a_k},$$

with n indexing households, $a = MM_k, MN_k, NN_k, NM_k$ indexing alternatives, and $k = Berlin, Hamburg, Munich$ indexing labor market-regions. $kids$ is a dummy vari-

[13] See Fassbender and Kluge (2006) for an overview of the project.

[14] Least squares estimation and prediction account for the survey weights reflecting individual sampling probabilities.

Figure 4.2: Labor Market Regions of Berlin, Hamburg, Munich

able indicating if there are children aged between one and 16 years in the household. *edu* gives the years of schooling associated with the highest degree achieved. *age* is reported in categories that each subsume five years of age.

Wages are taken from the regional sample of employees (*Beschäftigtenstichprobe*) of the Institute for Employment Research (IAB). These data constitute a two percent random sample of all German employees subject to social security contributions and report individual daily wages in €.[15] I merge the detailed individual wage information of this data with the survey data by age, gender, education level, and type of job. Thus, I assign the average wage of people of the same age, gender, education level, and type of job who chose the same alternative a in the same labor-market region k to the respective alternatives faced by the individual.

The third important determinant of the location decision is housing cost. The regional statistical offices provide data on the average prices for land in 2001 – 2004 in € per sqm at the county level, which serve as excellent indicators for the local cost of housing. However, in this context it is important to consider not only the price but also the quantity of housing space consumed.[16] Unfortunately, exact information on the individual demand for living space is not available. Therefore, I use the reported number of adults and children in each household along with official figures on average housing demand of one- (two-, three-or-more-) person households to proxy for the desired housing space of a household.[17] A further straight forward prediction from theory is that the demand for housing varies with income. Thus, the housing cost of each alternative is divided by the household income

[15]See Drews (2008) for a detailed description of the data.

[16]The monocentric city model predicts an inverse relationship between the demand for housing space and the price for housing.

[17]The figures stem from the German Statistical Office. Accordingly, the average housing space consumed by a one-person household in Germany in 2004 is 67.5 sqm (93.2 sqm for a two-person household, and 113.4 sqm for three-or-more-person households).

that is reported in the "Perspektive Deutschland" data. Thus, individual housing cost is calculated as

$$p_{n,a_k} = \frac{L_{a_k} h_n}{y_n},$$

where L_{a_k} denotes the average land price for alternative a in labor-market region k, h_n denotes the demand for housing of household n, and y_n is the reported household income net of taxes and including transfers. Note, that the household income variable includes capital income and therefore differs substantially from the wage variable. This way of constructing the housing cost variable ensures that the empirical analysis measures the valuation of housing cost of people having roughly the same demand for housing and the same level of income.

Table 4.1 reports summary statistics of the sample by alternatives a and aggregated over all three labor markets k.[18] The facts are as expected. Wages are higher for people working in metropolitan areas and housing costs in the center widely exceed those in nonmetropolitan regions, even though the latter are corrected for individual housing demand and income. Interestingly, the theoretical predictions are confirmed only partly by the descriptive statistics. In line with theory, average wages are higher for those who commute from the suburbs to the center compared to wages of non-commuters who reside in nonmetropolitan areas. In addition, wages for commuters to the metropolitan area are slightly higher than those of residents. However, the average numbers do not show such mark-ups for commuters living in the metropolitan area over the wages of their non-commuting neighbors. Commuting time is, of course, much higher for the alternatives that involve commuting. On average, individuals who chose different alternatives do not differ substantially in age. The average age for each alternative lies in the category of people aged 40 – 44 years. Furthermore, people who live in the center exhibit a higher amount of years of schooling and are less

[18]Summary statistics for each single labor-market region are presented in Tables A.1, A.2, and A.3 in Appendix B.

Table 4.1: Sample Means by Alternatives a^a

Variable	$a =$ MM	$a =$ MN	$a =$ NN	$a =$ NM	MM, MN	NN, NM
Location specific						
Commuting Time	30.6	37.6	25.3	47.3	31.1	33.1
Housing Cost	14.4	23.8	7.80	6.09	15.1	7.19
Wage	96.1	92.9	85.7	98.4	95.8	90.2
Individual						
Age	40-44	40-44	40-44	40-44	40-44	40-44
(Age Category)	(6.90)	(6.52)	(6.65)	(6.93)	(6.87)	(6.75)
Children	.211	.186	.306	.315	.209	.309
Education	11.6	11.8	10.8	11.1	11.6	10.9
Observations	20724	1865	8645	5634	22589	14279

Individual figures weighted by individual sampling probabilities.
^{a}: Aggregated over all three labor market-regions k.

likely to have children.

4.3.2 Econometric Specification

The objective of this paper is to estimate the influence of wages, housing costs, and commuting time on the household's simultaneous choice of residential and job location. The theoretical model on location choice outlined above naturally gives rise to estimation based on a random utility maximization (RUM) model. This sort of discrete choice models has its foundations in the seminal work of McFadden (1973). More precisely, I adopt the so called "random coefficients logit" approach where coefficients are allowed to vary over decision makers.[19] In this case, a household chooses a combination of residence and working place among the four alternatives a ($a = MM_k, MN_k, NN_k, NM_k$) which each are located in one of the labor market regions k ($k = Berlin, Hamburg, Munich$). Note, that this setting implies a nested approach, where the individual chooses one alternative a after having decided to work and reside in labor market-region (*i. e.* nest) k. In the following, I suppress the subscript k for convenience, as each element that varies over a also varies over k. The indirect utility that household n derives from choosing alternative a is

$$\widetilde{V}_{n,a} = V_{n,a} + \varepsilon_{n,a}, \tag{4.5}$$

where $V_{n,a}$ is the deterministic part of indirect utility, which depends on observable characteristics of households and alternatives, and $\varepsilon_{n,a}$ is an unobserved random term that is identically and independently drawn from an extreme value type I distribution. Analo-

[19] This approach is also known as "mixed logit" or "error components logit" and has been applied in many studies, e. g. Bhat (1998), Brownstone and Train (1999), or Train (1998). For an excellent introduction, see Train (2003).

gously to equation (4.4), the household chooses alternative a^* if and only if

$$\widetilde{V}_{n,a^*} \geq \widetilde{V}_{n,a} \quad \forall a \neq a^*. \tag{4.6}$$

The choice of factors that influence the deterministic part of indirect utility is guided by the theoretical model. According to considerations about the distribution of tastes for these factors in the population, $V_{n,a}$ can be written as:

$$V_{n,a} = \alpha X_{n,a} + \beta_n Z_{n,a}, \tag{4.7}$$

where the tastes for the factors contained in $X_{n,a}$ are assumed to be constant across households, while those contained in $Z_{n,a}$ are assumed to vary randomly over households. Note in this context, that the vector of coefficients β is subscripted with n while α is not.

In the most general form of equation (4.7),

$$X_{n,a} = age_n \iota^{com} + kids_n \iota^{com} + edu_n \iota^{com} + age_n \iota^M + kids_n \iota^M + edu_n \iota^M + w_{n,a}, \tag{4.8}$$

where ι^{com} is an indicator variable for people who commute (*i. e.* $a = MN, NM$), and ι^M is an indicator of people who live in the central metropolitan area of their respective labor market-region (*i. e.* $a = MM, MN$), and

$$Z_{n,a} = \delta^a + \delta^k + p_{n,a} + t_{n,a}, \tag{4.9}$$

where δ^a represents a vector of fixed effects for each alternative $a = MM, MN, NN, NM$, and δ^k represents a vector of fixed effects for each labor-market region
$k = Berlin, Hamburg, Munich$.

The influence of the determinants of choice contained in $X_{n,a}$ is assumed to be constant across households. The indicator variables ι^{com} and ι^M are designed to capture that the households' tastes for living in the center or for commuting might systematically vary with individual characteristics like age, children, or education.[20] Furthermore, including wages in $X_{n,a}$ amounts to assuming that individual tastes for wages are identical among households.[21]

In contrast, the coefficients of the variables in $Z_{n,a}$ are assumed to vary randomly over households. For example, the individual tastes for commuting costs in the population, expressed by the coefficient β_n^t, are assumed to follow a lognormal distribution with parameters θ to be estimated. This distribution is also called the mixing distribution. Adopting such a specification accounts for two issues. First, the coefficient on commuting time is expected to be negative in the entire population as it is associated with a cost. Thus, the negative of commuting time is used in estimation such that its lognormal distribution ensures that the coefficient is negative for each individual. Second, even as commuting is generally disliked, there might still be substantial unobserved variation in personal tastes for commuting, beyond the systematic variation with age, education, and children. Imagine, for example, people who travel to work by public transport: Some might at least enjoy to spend traveling time reading a book or newspaper, while others explicitly dislike crowded busses or trains. Similarly, some of the commuters who travel by car might be more fond of driving as such than others. A similar reasoning holds with respect to housing

[20]Official figures for Germany suggest that commuting patterns indeed vary substantially with age, gender, education, and income. See Statistisches Bundesamt (2005) for details.

[21]Though arbitrary, it seems realistic that the variation in tastes for wages is less pronounced than that in tastes for commuting time or housing cost.

costs. In this particular case, including $p_{n,a}$ in $Z_{n,a}$ amounts to assuming that individual tastes for housing costs vary even for households having the same income and the same demand for living space.[22] Analogously to commuting time, the coefficient on housing cost is assumed to be lognormally distributed and thus the negative of housing cost is used in estimation.

As outlined above, the empirical setting exhibits a nested structure as the choice of four alternatives is analyzed in three different labor market-regions. To take account of this structure, $Z_{n,a}$ includes indicator variables for each nest (*i. e.* for each labor market region), δ^k, which are assumed to have a normal distribution. As the random coefficients on the δ^k's enter only the utility of alternatives within the respective nest k, possible correlation within a labor-market region is captured and no correlation between alternatives of different nests is induced.[23]

An obvious issue with the adopted setting is that two respective alternatives are always somehow similar to each other as they share one feature. There are, for example, two alternatives involving commuting (MN, NM) and two alternatives that imply living in the metropolitan center (MM, MN). It is therefore not reasonable to expect tastes for these alternatives to be independent from each other a priori, an assumption that would hold in classic multinomial logit models and is known as independence of irrelevant alternatives (IIA). For this reason, indicator variables δ^a that identify the average taste for each alternative within each nest are included in $Z_{n,a}$, assuming that their coefficients are normally distributed in the population. The estimation of the parameters of the distributions of the coefficients β_n thereby explicitly allows for arbitrary correlation patterns between the

[22]However, one can think of arguments in favor of the hypothesis that tastes for housing costs are almost identically distributed for people with the same income and demand for space. Therefore, different specifications are presented, where the housing cost variable enters $X_{n,a}$ or $Z_{n,a}$, respectively.

[23]This approach is analogous to a nested logit model, which itself is a special case of the mixed logit model. See Train (2003) for a discussion.

variables contained in $Z_{n,a}$. Thus, any unobserved correlation over alternatives is captured by estimating the parameters of the distribution of the coefficients of the δ^a's. Moreover, this approach also takes care of possible differences in the variance of unobserved factors between alternatives, since the variance of tastes for each alternative is explicitly estimated. The assumption that the error terms $\varepsilon_{n,a}$ are homoscedastic and i. i. d. extreme value therefore remains valid.[24] Note, however, that the alternative specific constants also capture the average tastes for local characteristics of the alternatives, that have been labeled amenities in the theoretical model of the previous section.

To be precise, let β^δ be the vector of coefficients on all δ^a and δ^k, and let β^c be the vector of coefficients on commuting time and housing costs. Then, I assume that $\beta^\delta \sim N(b^\delta, \Omega)$ and that $ln(\beta^c) \sim N(b^c, \Omega)$ for general Ω. Hence, the exact parameters to be estimated are the means of the (natural logarithms of) coefficients b^δ (b^c), along with a lower triangular Choleski factor L of Ω, such that $LL' = \Omega$.

4.4 Results

This section reports the estimation results of several specifications of estimation equation (4.5), given equations (4.7), (4.8), and (4.9).[25]

[24]See Train (2003) for a discussion.

[25]All estimations, simulations and calculations are carried out using the mixlogit Stata command by Hole (2007), and my own Stata/Mata code. The code may be obtained from the author on request.

4.4.1 Estimation

The results of the mixed logit model are reported in Table 4.2. The coefficients on the alternative specific constants within each nest, δ^a, as well as those on the labor-market region specific fixed effects, δ^k, are estimated together with their standard deviations in all specifications. It is assumed that they are correlated and follow a normal distribution with the reported means and standard deviations. In the specifications reported in columns 1 and 2 of Table 4.2 only the coefficient on commuting time is allowed to vary over decision makers, while wages and housing cost are modeled to be valued identically in the population. The estimations reported in columns 3 and 4 treat housing costs as an additional random coefficient. Furthermore, the specification reported in column 2 (column 4) is identical to that of column 1 (column 3) but includes some basic individual characteristics as fixed coefficients. The results and simulations reported in the following sections are all based on the estimation presented in column 3.

In general, the empirical model clearly confirms the predictions from economic theory as all coefficients show the expected signs and are precisely estimated. Higher wages attract people, while higher commuting time and higher housing costs make an alternative less likely to be chosen. Furthermore, the maximum simulated likelihood estimation procedure yields very robust results, as the coefficients on these variables are quantitatively comparable across the different specifications. The estimated standard deviations of the random parameters are highly significant in all cases, indicating that tastes for commuting time and housing costs indeed do vary in the population. Note, that this variation may be due to unobservable characteristics as well as to observable ones, which are not included in the model. However, the estimated standard deviations remain significantly different from zero after inclusion of some basic personal characteristics (columns 2 and 4). Thus, I find significant variation in tastes for commuting time and housing costs even for similar types

Table 4.2: Results of the Mixed Logit Estimation

	1		2		3		4	
Variable	*Parameter*	*SE*	*Parameter*	*SE*	*Parameter*	*SE*	*Parameter*	*SE*
MM (mean of coefficient)	6.76***	(1.31)	4.74***	(.665)	3.05***	(.249)	3.58***	(.338)
MM (SD of coefficient)	4.99***	(.974)	5.93***	(1.01)	2.30***	(.337)	4.27***	(.565)
NN (mean of coefficient)	4.86***	(1.27)	3.32***	(.700)	.757***	(.271)	1.49***	(.372)
NN (SD of coefficient)	3.06***	(.837)	2.38***	(.432)	.986***	(.104)	.893***	(.177)
NM (mean of coefficient)	3.11**	(1.43)	-.498	(.789)	-1.61**	(.642)	-.723	(.469)
NM (SD of coefficient)	9.08***	(.911)	4.49***	(.726)	5.44***	(.632)	3.61***	(.497)
BERLIN (mean of coefficient)	.725***	(.071)	.530***	(.062)	1.14***	(.154)	.910***	(.201)
BERLIN (SD of coefficient)	.605**	(.242)	.698***	(.155)	1.95***	(.290)	1.70***	(.389)
MUNICH (mean of coefficient)	.551***	(.064)	.682***	(.049)	1.52***	(.145)	1.53***	(.179)
MUNICH (SD of coefficient)	.879***	(.178)	1.05***	(.176)	3.06***	(.340)	2.95***	(.415)
Commuting Time (mean of ln(coefficient))	-3.49***	(.130)	-6.61***	(1.26)	-4.24***	(.154)	-5.55***	(.344)
Commuting Time (SD of ln(coefficient))	1.07***	(.087)	1.97***	(.583)	1.68***	(.078)	2.16***	(.136)
Housing Cost (mean of ln(coefficient))^a	-.035***	(.001)	-.036***	(.002)	-3.35***	(.077)	-3.33***	(.122)
Housing Cost (SD of ln(coefficient))					1.47***	(.065)	1.57***	(.084)
Wage (coefficient)	.005***	(.001)	.003***	(.001)	.005***	(.002)	.003**	(.002)
Commute X Age (coefficient)			.073***	(.024)			.043***	(.015)
Commute X Children (coefficient)			.866***	(.213)			.611***	(.105)
Commute X Education (coefficient)			-.021	(.014)			-.008	(.010)
M X Age (coefficient)			-.198***	(.026)			-.147***	(.017)
M X Children (coefficient)			-1.52***	(.188)			-1.15***	(.117)
M X Education (coefficient)			.146***	(.020)			.114***	(.011)
SLL	-78475.92		-78151.53		-78341.89		-78002.29	

Dependent variable: Choice of alternative a, with $a = MM_k, MN_k, NN_k, NM_k$, and $k = Berlin, Hamburg, Munich$. Omitted categories of fixed effects are: $\delta^a = MN$, $\delta^k = Hamburg$. All reported standard deviations are calculated on the basis of the estimated Choleski factors L. ^{a}: Reported parameter corresponds to mean of ln(coefficient) in columns 3 and 4, and to coefficient in columns 1 and 2. *** denotes significance at 1% level (** at 5%, * at 10%). 442416 observations correspond to 36868 individuals. 100 Halton draws used for simulation.

Table 4.3: Lognormal Distributed Coefficients

	1	2	3	4
Commuting Time (mean of coefficient)	.054	.009	.060	.040
Commuting Time (SD of coefficient)	.079	.064	.240	.409
Housing Cost (mean of coefficient)			.103	.122
Housing Cost (SD of coefficient)			.284	.397

Columns 1, 2, 3, and 4 directly refer to columns 1, 2, 3, and 4 of Table 4.2.

of households.[26] The parameters on commuting time and housing cost reported in Table 4.2 are the means and standard deviations of $ln(\beta)$. The associated means and standard deviations of β are given in Table 4.3.[27] The standard deviations of the coefficients on commuting time and housing cost are relatively high compared to the coefficients themselves. Apparently, the degree of variation in tastes in the population is of considerable magnitude. This result is not really surprising as the individual cost per minute of commuting time is very likely to differ greatly, with observable characteristics like age or income, as well as with unobservable tastes for circumstances involved with commuting (e. g. driving a car or using means of public transport). One can easily think of similar arguments regarding the taste variation for housing costs.

In the main specification reported in column 3 of Table 4.2, the estimated means and standard deviations of the coefficients on the fixed effects for alternatives are all significantly different from zero. According to the estimates, there is substantial variation in tastes for

[26]Remember that the housing cost variable already explicitly captures the housing cost for households of equal size and income.

[27]The mean of β is calculated as $exp(b+(s^2/2))$, its standard deviation is calculated as $exp(b+(s^2/2)) * \sqrt{exp(s^2)-1}$, where b and s represent the estimated mean and standard deviation of the distribution of $ln(\beta)$.

combinations of working place and place of residence. In particular, the distribution of the valuation of the "typical" commuting option to live in the nonmetropolitan area and work in the central city seems to be very dispersed. Its mean is even negative, which means that, on average, this alternative is disliked compared to the option to commute from the center to the nonmetropolitan area. More precisely, the estimated distribution of the coefficient implies that roughly 62% of households prefer the omitted alternative, while the other 38% prefer to commute from the suburbs to the center. This seems a little surprising but might be due to lower commuting time per distance in the direction from the center to the suburbs. In contrast, both non-commuting alternatives are on average preferred to the omitted alternative. The distributions of these coefficients imply that only around 9% (22%) of households place a negative value on the alternative to live and work in the metropolitan area (in the nonmetropolitan area) when compared to the alternative to commute from the center to the suburbs. With respect to the primary choice of labor-market region, both Berlin and Munich seem to be preferred to Hamburg on average. However, the distributions of these coefficients show considerable dispersion, too, with roughly one third of the population preferring Hamburg to both of the cities.

All reported standard deviations are calculated on the basis of the estimated Choleski factors L. The elements of the corresponding variance-covariance matrix Ω are almost all estimated significantly at at least the 5% level, indicating that there does exist sizeable correlation between the coefficients.[28] The implied correlation pattern is reported in Table 4.4. The correlation between $a = MM$, $a = NN$, and $a = NM$ is positive implying that households preferring the option to live and work in the center to the option of commuting from the center to the suburbs would also favor the two other alternatives. The correlation between housing cost and commuting time is positive and fairly large. Households with

[28]In fact, only the covariance of $\delta^{a=MM}$ and housing cost and the covariance of $\delta^{a=NM}$ and $\delta^{a=NN}$ are insignificant. While the former result is not of much interest, the latter is surprising. It implies that there is no significant correlation between tastes for the two alternatives that both involve residing in the nonmetropolitan area.

Table 4.4: Correlation Matrix

	MM	NN	NM	B	M	Com	Hous
MM	1						
NN	.529	1					
NM	.420	*-.164*	1				
BERLIN	-.083	-.682	-.182	1			
MUNICH	-.376	-.830	-.187	.898	1		
Commuting Time	.099	-.626	.339	.663	.761	1	
Housing Cost	*-.059*	-.639	.303	.535	.741	.966	1

Calculations based on estimates reported in column 3 of Table 4.2. Figures in italics are statistically not significant.

above average valuation of housing cost obviously also place higher than average values on commuting time. This is interesting as the high degree of correlation indicates that both types of cost are valued together compared to the other variables. Furthermore, the coefficients on the labor market fixed effects are strongly correlated. Again, this positive correlation is not surprising as these variables form a group relative to the other covariates.

The specifications reported in columns 2 and 4 of Table 4.2 further include individual characteristics as fixed coefficients. The estimates on the personal characteristics provide further interesting insights. Accordingly, older people are less likely to live in the metropolitan area, but are more likely to commute, while people with higher education clearly prefer city centers and tend to commute less. Households with children apparently have a higher probability to commute and to live in nonmetropolitan areas, even if the higher demand for living space is taken into account via the housing cost variable.

The quantitative implications of the model are based on the predictions it delivers. Given the characteristics of each alternative, the predicted individual probability of choosing alternative a_k is

$$P_{n,a_k}(\widehat{\theta}) = \int \frac{exp(V_{n,a_k})}{\sum_j exp(V_{n,j})} f(\beta|\widehat{\theta})d(\beta). \tag{4.10}$$

Table 4.5 reports the observed (column 1) and the predicted number of households (column 2) choosing each of the twelve alternatives. The figures in column 2 represent the sums of the predicted individual probabilities of picking a particular alternative a_k:

$$\sum_n P_{n,a_k}(\widehat{\theta}). \tag{4.11}$$

The predictive power of the model is quite good as the predicted choice pattern very closely resembles the observed pattern. The appropriateness of the econometric model is further confirmed by very exact predictions of the distribution of individual commuting times, wages, and housing costs. This fact is further exploited in section 4.5, where the effects of policy measures are simulated.

4.4.2 Elasticities

The coefficients of the mixed logit model have no direct interpretation, so I calculate the corresponding comparative static elasticities. These figures measure the *ceteris paribus* impact of an alternative specific variable on the choice of this (or another) alternative. The resulting elasticities of changes in wages, housing costs, and commuting time within each labor market region are reported in Appendix B. As the focus of this analysis is not on the choice of the labor market region, only the elasticities of changes within one respective labor market region are reported.[29] Note, that in the employed mixed logit model the

[29] Nevertheless, the reported elasticities are calculated allowing each household to choose from all twelve alternatives. The full set of all comparative static elasticities for changes in one exogenous variable would give a matrix with $12 \times 12 = 144$ elements. Thus, the reported Tables in the appendix represent the 4×4 matrices on the "diagonal" of the corresponding full set-matrices.

percentage change in the probability for one alternative given a percentage change in one characteristic of this alternative (or any other alternative) depends on the characteristics of all alternatives. Thus, elasticities are not symmetric as in simple logit models. To give an example of how to read Table A.4, consider a one percent increase in commuting time for a household that resides and works in the metropolitan area of Hamburg. This lowers the probability of this alternative to be chosen by 0.321%. At the same time, the probability that the household chooses to live in the central city of Hamburg and to commute to the suburbs increases by 0.022%. Analogously, the probability to live and work in the suburbs increases by 0.059%, and the incentive to commute from the suburbs to the center increases by 0.044% due to the rise in commuting time in alternative $a = MM$. In contrast, a one percent increase in the commuting time for alternative $a = MN$ ($a = NN$, $a = NM$) increases the probability that a household chooses to reside and work in the metropolitan area of Hamburg by 0.002% (0.017%, 0.025%). Note, that the elasticities for commuting time are highest in Berlin, where both the city center and the nonmetropolitan area are more spread out than in the other two regions. In general, households residing in the nonmetropolitan areas are much more sensitive to changes in commuting time than their counterparts in the centers, since they already face longer commutes. The wage elasticities are relatively similar across labor market-regions. Apparently, wage increases for households that commute from the center to the periphery have the strongest impact. The elasticities with respect to housing cost are relatively low compared to those of commuting time and wages, with the exception of Munich. In particular, households residing in the central area of Munich react remarkably sensitive to changes in housing cost. This is most probably due to the very high level of the cost of housing in the Bavarian capital.

These comparative static elasticities are valid if one thinks of individual households. However, by construction, an increase in wages for alternative $a = MM$ implies an increase in wages for alternative $a = NM$, too. Therefore, more general patterns of the effects of changes in the exogenous variables are reported in section 4.5.

4.4.3 Consumer Surplus

Not only policy makers might be interested in how people value the effects of particular policy measures. A result readily offered by this kind of analysis is the estimated willingness to pay for changes in wages, commuting time, and housing cost. Given the coefficients β from column 3 of Table 4.2, the compensating variation for each individual household that is associated with a change in attributes of the alternatives is calculated following Train (1998) and Cherchi and Polak (2005):

$$CV_n = \int \frac{1}{\beta^w} \left(ln \left(\sum_{a_k} exp(V_{n,a_k}^{pre}) \right) - ln \left(\sum_{a_k} exp(V_{n,a_k}^{post}) \right) \right) f(\beta|\theta^{pre}) d(\beta), \qquad (4.12)$$

where the coefficient on wages, β^w, represents the marginal utility of income[30], and *pre* (*post*) refers to the situation before (after) the change.

Accordingly, the average compensating variation in the population associated with a 10% increase in commuting time (housing cost, wages) amounts to € 37.06 (€ 14.34, € 10.97).[31] In other words, an amount of € 37.06 in terms of daily wage is necessary to compensate households for the extended daily one-way commute. This is more than double the willingness to pay to avoid a deterioration of housing cost relative to income of the same magnitude. Further case specific results on consumer surplus are reported in the following section, where the overall effects of particular policy measures are discussed.

[30]This specification suggests that the marginal utility of income is independent from income. Train (2003) points out that this assumption is innocuous if the changes in consumer surplus are small relative to income, which is arguably the case in the analysis at hand.

[31]The integral is solved by simulation using 100 Halton draws.

4.5 Quantitative Implications

The estimated model allows to carry out counterfactual simulations of the effects of policy measures that affect the analyzed variables. Two showcase scenarios are assessed on the basis of the model reported in column 3 of Table 4.2.

Scenario 1 *("Pendlerpauschale") An existing tax deductible for long distance-commuters is cut by German authorities, leading to a decrease in wages of commuters between metropolitan and nonmetropolitan areas of 10%.*

This scenario is designed to resemble the planned cut in the so called "Pendlerpauschale" in Germany, which came into effect in 2007 and has been rescinded after being halted by the German Federal Constitutional Court (Bundesverfassungsgericht) in the end of 2008. This "Entfernungspauschale" is an income tax-deductible of € 0.30 per kilometer of (daily) commuting distance. Its roots date back as far as 1920. The described cut planned to grant the deductible only for commuting distances exceeding 20 kilometers instead of the entire distance. Columns 3 and 4 of Table 4.5 show the effects of this political measure on the spatial distribution of households in the three analyzed labor market-regions. Column 3 reports the predicted number of households that choose each option after the cut of the subsidy, calculated according to equation (4.11). The implied percentage change compared to the situation before the policy measure (as shown in column 2) is reported in column 4. Little surprisingly, the wage drop for the "commuting alternatives" leads to a decrease in households that choose these alternatives in each of the regions of Hamburg, Berlin, and Munich. In contrast, in each region the population that works and lives either in the center or in the suburbs rises after the subsidy cut. The alternative that experiences the largest relative drop in attractiveness is the option to commute from the center of Hamburg to its suburbs, where the number of choices decreases by 4.06%. The alternative that gains

Table 4.5: Model Predictions I: Number of Households

				Scenario 1		Scenario 2	
		Observed	Predicted	Predicted	Change	Predicted	Change
Hamburg:	MM	5460	5577	5606	.511	5576	-.019
	MN	349	376	360	-4.06	376	-.028
	NN	1988	1955	1967	.643	1954	-.023
	NM	1922	1912	1885	-1.42	1912	-.008
Berlin:	MM	10848	10450	10495	.426	10450	.001
	MN	580	559	542	-3.00	560	.182
	NN	3003	2640	2655	.552	2644	.157
	NM	1685	1649	1629	-1.20	1649	.008
Munich:	MM	4416	4922	4947	.515	4921	-.029
	MN	936	1049	1007	-3.96	1049	-.042
	NN	3654	3747	3778	.833	3746	-.040
	NM	2027	2031	1995	-1.79	2031	-.013

Calculations based on estimates reported in column 3 of Table 4.2. Individual choice probabilities are simulated using 100 Halton draws.

most appeal to households is to live and work in the nonmetropolitan area of Munich, with an increase of 0.83%. Note, however, that the subsidy also leads to changes in the choice of labor-market region. While Hamburg looses one inhabitant, 22 households choose alternatives in Berlin instead of Munich as a consequence of the subsidy cut. The reason for this pattern is that average wages and relative housing costs in Munich are above the sample average, while the housing cost in Berlin is far below average. Given this constellation, the uniform percentage decrease in wages of commuters draws households from the high cost alternatives in Munich to the low cost region of Berlin. Although interesting, the choice of the labor-market region itself is not the focus of this paper. Therefore, Table 4.6 reports the average predicted effects of scenarios 1 and 2 for the four intra-regional alternatives ($a = MM, MN, NN, NM$) only. The figures in Table 4.6 are the sums of the individual choice probabilities for the respective alternatives a, averaged over the three labor market-regions k:

$$\frac{1}{K}\sum_{k}^{I}\sum_{n}^{N}\overline{P}_{n,a_k}(\widehat{\theta}),$$

where the individual choice probabilities are now calculated under the implicit assumption that the choice of the labor-market region is irreversible:

$$\overline{P}_{n,a_k}(\widehat{\theta}) = \int \frac{exp(V_{n,a_k})}{\sum_j exp(V_{n,j_k})} f(\beta|\widehat{\theta})d(\beta).$$

As can be seen from Table 4.6, the average effects of the subsidy cut on the choice of the alternatives within regions does not differ much from that seen in Table 4.5. A look at the aggregated effects is a little more revealing, though. The political measure leads to a predicted increase in the population of metropolitan areas of 0.09%, while the population of nonmetropolitan areas drops by 0.14%. The total number of households that commute between centers and suburbs drops sharply by almost 2% in response to the subsidy cut.

Table 4.6: Model Predictions II: Number of Households

			Scenario 1		Scenario 2	
	Observed	Predicted	Predicted	Change	Predicted	Change
MM	20724	20432	20526	.464	20429	-.012
MN	1865	2119	2044	-3.53	2119	.017
NN	8645	8562	8623	.706	8565	.026
NM	5634	5755	5675	-1.40	5755	-.004
M	22589	22550	22570	.089	22548	-.009
N	14279	14318	14298	-.140	14320	.014
COM	7499	7874	7719	-1.97	7874	.002

Calculations based on estimates reported in column 3 of Table 4.2. Individual choice probabilities are simulated using 100 Halton draws.

The present model allows to estimate the willingness to pay for the subsidy cut in scenario 1. The individual household's compensating variation associated with the political measure is simulated according to equation (4.12), where 100 Halton draws are used to simulate the integral. The resulting average change in consumer surplus that is associated with the cut-back of the subsidy to commuters amounts to € 2.28.

Scenario 2 *(Minimum Wage) The German government introduces a uniform minimum wage of € 7.50.*

Scenario 2 simulates the location choices of households if all wages below a threshold of € 7.50 were lifted onto this level. In the presence of a wage premium in agglomerations, which is clearly indicated by the summary statistics of the present analysis,[32] this should

[32]See Lehmer and Möller (2007) and Büttner and Ebertz (2009) for quantitative evidence on the so called urban wage premium in Germany.

lead to a stronger relative increase in average wages in the nonmetropolitan areas. Büttner and Ebertz (2009) point out that under decreasing marginal returns to labor in regional production, a uniform minimum wage leads to a shift of population from rural to agglomerated regions. However, the present simulations can only focus on household decisions and do not account for the production side. Thus, the outcome will be different in that we expect the choice probabilities of alternatives that gain most through the introduction of the minimum wage to rise. The figures in columns 5 and 6 of Table 4.5 confirm this expectation, although the quantitative effects are fairly small. If households were free to choose from all options, the minimum wage of € 7.50 would draw decision makers from virtually all alternatives in Hamburg and Munich to all of the options in the region of Berlin. Especially the alternatives that involve working in the periphery of Berlin experience a strong rise in choice probability, with 0.18% for commuting from the center and 0.16% for living and working in the nonmetropolitan area. This is because wages in the East-German periphery of Berlin are well below the sample average and the percentage of incomes below the minimum wage of € 7.50 is by far highest there. In contrast, the largest population losses are induced for the alternatives to commute to the nonmetropolitan area of Munich, and to live and work in that area, respectively. This is exactly the peripheral region in the sample that exhibits the highest wages and the lowest incidence of the minimum wage. In total, the model predicts a population gain of 6 households for Berlin and losses of 2 households for Hamburg and 4 households for Munich, respectively. As the wage differences between nests are relatively large, the results in Table 4.6 provide much more insights regarding the effect of the minimum wage on the center–periphery system within a labor-market region. Given that the choice of labor-market region is fixed, the minimum wage of € 7.50 leads to an average reduction of households that choose to live and work in the metropolitan areas of 0.012%. The option to commute to the metropolitan area is chosen 0.004% less. The relative stronger growth of wages in the nonmetropolitan areas leads to an increase in the number of households that choose to work there: The number of choices in favor of living and working in the periphery (living in the metro area and working in the periphery) increases by 0.026% (0.017%). In total, we see a slight population gain for nonmetropolitan areas (0.014%), while metropolitan area population drops by 0.009%. Furthermore, the introduction of the minimum wage leads to an increase in the overall number of commuters of 0.002%.

As in the previous scenario, I use simulation techniques to estimate the individual willingness to pay for the introduction of the minimum wage according to equation (4.12). The average compensating variation associated with the introduction of a minimum wage of € 7.50 is € 0.10. Note, that this figure is positive since this simulation does not account for possible employment effects. In fact, the simulation assumes that wages at each alternative are independent of employment at that alternative.

While it is clear that the present model can only predict household behavior and has no power to consider any equilibrium effects determined through the interplay with the production sector, another important caveat has to be kept in mind regarding the simulated effects. Similarly, any adjustments on the housing markets provoked by shifts in the population are not incorporated in the model. The same is true for possible nonlinear congestion effects on commuting time.

4.6 Conclusion

This paper empirically quantifies the effects of wages, housing costs, and commuting time on the joint residential and job location choice of households. Applying discrete choice methods to a large set of micro-data allows a comprehensive empirical analysis of the three most important economic determinants of location choice. The analysis focuses on the household's decision to live and work either in the central metropolitan area, or the surrounding nonmetropolitan area, or to commute between the two. Objects of investigation are the regional labor markets constituted by the urban centers of the largest German cities Berlin, Hamburg, and Munich. A mixed logit approach is employed where coefficients are allowed to vary randomly over decision makers instead of being constant. This estimation strategy avoids the restrictive IIA assumption that is implicit in simple multinomial logit estimation. Moreover, arbitrary correlation patterns of coefficients are explicitly allowed for as correlation between tastes for the alternatives is very likely in the adopted choice setting.

The estimates fully confirm the important role of wages, housing costs, and commuting time for individual location choice, as predicted by economic theory. However, the results show that tastes for commuting time and housing costs do vary substantially within the population. Estimated elasticities show how changes in wages, housing costs, or commuting time affect the distribution of households between metropolitan and nonmetropolitan areas. Interestingly, there are no systematic differences in the magnitude of the impacts between the three factors. However, the effects of the economic determinants do vary over alternatives. To illustrate the quantitative implications of these results, two counterfactual scenarios are predicted. Accordingly, a general 10% cut in the wages of commuters would lead to an increase in urban population of 0.09% and a decrease in the population of nonmetropolitan areas of 0.14%. Total commuting decreases by almost 2%. Furthermore, the introduction of a uniform minimum wage of € 7.50 leads to a decrease (increase) of urban (rural) population of 0.009% (0.014%). In addition, both political measures result in minor shifts of the population between the three labor market-regions. The estimated overall willingness to pay to avoid the wage drop amounts to € 2.28, while the change in consumer surplus associated with the minimum wage of € 7.50 is € 0.10.

Economic theory also emphasizes the role of local amenities for the household's location choice. The present study captures such effects by alternative- and region specific fixed effects only. Any particular amenities are not explicitly addressed due to the excessive time cost and technical limits that are implied by the computational complexity of the applied estimation method. However, the estimation of willingness-to-pay figures for local amenities using appropriate, simulation based discrete choice methods remains a worthwhile aim for future research.

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Appendix A: Counties of the (Non)Metropolitan Areas

Labor-market region of Hamburg:

- Metropolitan Area: Urban county of Hamburg (Kreisfreie Stadt Hamburg).
- Nonmetropolitan Area: Counties (Landkreise) Harburg, Rotenburg (Wümme), Stade, Herzogtum Lauenburg, Pinneberg, Segeberg, Stormarn.

Labor-market region of Berlin:

- Metropolitan Area: Urban county of Berlin (Kreisfreie Stadt Berlin).
- Nonmetropolitan Area: Urban counties (kreisfreie Städte) Frankfurt a. d. Oder, Brandenburg a. d. Havel, Potsdam. Counties (Landkreise) Oberhavel, Barnim,

Märkisch Oderland, Oder-Spree, Dahme-Spreewald, Havelland, Potsdam-Mittelmark, Teltow-Fläming.

Labor-market region of Munich:

- Metropolitan Area: Urban county of Munich (Kreisfreie Stadt München).
- Nonmetropolitan Area: Counties (Landkreise) Dachau, Ebersberg, Erding, Freising, Fürstenfeldbruck, Landsberg a. Lech, München, Starnberg.

Appendix B: Summary Statistics and Comparative Static Elasticities

Table A.1: Sample Means by Alternatives a: Berlin

Variable	$a = MM$	$a = MN$	$a = NN$	$a = NM$
Location specific				
Commuting Time	33.4	46.4	26.4	51.2
Housing Cost	7.97	7.42	3.32	3.04
Wage	90.1	75.2	72.1	87.6
Individual				
Age	40-44	40-44	40-44	40-44
(Age Category)	(7.07)	(6.48)	(6.70)	(6.85)
Children	.233	.262	.316	.360
Education	11.5	11.7	11.0	11.0
Observations	10848	580	3003	1685

Individual figures weighted by individual sampling probabilities.

Table A.2: Sample Means by Alternatives a: Hamburg

Variable	$a = MM$	$a = MN$	$a = NN$	$a = NM$
Location specific				
Commuting Time	28.2	36.8	21.3	46.5
Housing Cost	13.9	13.8	4.97	4.24
Wage	99.8	95.5	89.6	104
Individual				
Age	40-44	40-44	40-44	40-44
(Age Category)	(6.82)	(6.59)	(7.01)	(7.17)
Children	.188	.140	.349	.335
Education	11.5	11.4	10.5	10.9
Observations	5460	349	1988	1922

Individual figures weighted by individual sampling probabilities.

Table A.3: Sample Means by Alternatives a: Munich

Variable	$a = MM$	$a = MN$	$a = NN$	$a = NM$
Location specific				
Commuting Time	26.2	32.9	26.8	42.8
Housing Cost	34.0	38.2	15.2	12.3
Wage	108	102	99.0	107
Individual				
Age	40-44	40-44	35-39	40-44
(Age Category)	(6.54)	(6.51)	(6.34)	(6.79)
Children	.187	.162	.262	.233
Education	12.1	12.1	10.8	11.5
Observations	4416	936	3654	2027

Individual figures weighted by individual sampling probabilities.

Table A.4: Comparative Static Elasticities

	Commuting Time: Hamburg					*Commuting Time: Berlin*			
	MM	MN	NN	NM		MM	MN	NN	NM
MM	-.321	.002	.017	.025	MM	-.705	.010	.145	.061
MN	.022	-.261	.018	.011	MN	.137	-.846	.068	.020
NN	.059	.005	-.755	.024	NN	.715	.024	-1.74	.074
NM	.044	.002	.012	-.821	NM	.262	.006	.064	-1.93

	Commuting Time: Munich			
	MM	MN	NN	NM
MM	-.509	.019	.071	.038
MN	.069	-.505	.141	.032
NN	.096	.049	-.756	.059
NM	.064	.014	.069	-1.46

	Housing Cost: Hamburg					*Housing Cost: Berlin*			
	MM	MN	NN	NM		MM	MN	NN	NM
MM	-.237	.002	.007	.005	MM	-.205	.003	.020	.004
MN	.033	-.243	.013	.004	MN	.053	-.237	.015	.002
NN	.054	.006	-.220	.006	NN	.192	.007	-.225	.006
NM	.043	.002	.006	-.148	NM	.076	.002	.011	-.150

	Housing Cost: Munich			
	MM	MN	NN	NM
MM	-1.08	.035	.068	.019
MN	.177	-1.11	.188	.023
NN	.209	.106	-.651	.035
NM	.108	.025	.062	-.832

	Wage: Hamburg					*Wage: Berlin*			
	MM	MN	NN	NM		MM	MN	NN	NM
MM	.326	-.006	-.041	-.022	MM	.245	-.004	-.022	-.011
MN	-.100	.505	-.106	-.019	MN	-.098	.411	-.042	-.007
NN	-.125	-.020	.383	-.014	NN	-.104	-.009	.306	-.006
NM	-.066	-.004	-.014	.309	NM	-.069	-.002	-.008	.371

	Wage: Munich			
	MM	MN	NN	NM
MM	.425	-.019	-.057	-.012
MN	-.090	.494	-.167	-.016
NN	-.075	-.045	.362	-.014
NM	-.032	-.009	-.025	.356

Calculations based on estimates reported in column 3 of Table 4.2. Individual elasticities are simulated using 100 Halton draws.

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Ich versichere hiermit eidesstattlich, dass ich die vorliegende Arbeit selbständig und ohne fremde Hilfe verfasst habe. Die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sowie mir gegebene Anregungen sind als solche kenntlich gemacht. Die Arbeit wurde bisher keiner anderen Prüfungsbehörde vorgelegt und auch noch nicht veröffentlicht.

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