The Capitalization of Non-Market Attributes into Regional Housing Rents and Wages: Evidence on German Functional Labor Market Areas

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Abstract

This paper extends existing research on regional quality of life in Germany by newly estimating the role of region-specific (dis-)amenities in the determination of regional housing rents and wages. Different from previous studies, the empirical analysis draws on functional labor market areas recently delineated by Kosfeld and Werner [Raumf Raumordn (2012) 70: 49-64] rather than administrative jurisdictions, circumventing problems of spatial autocorrelation. Consistent with cross-region spatial equilibrium, the results indicate that labor market area heterogeneity in housing rents and wages is closely related to differences in non-market attributes that affect household utility. The results enable the construction of a comprehensive ranking of regional quality of life which can be directly compared to the findings of previous studies.

Keywords: Functional labor market areas, Non-market (dis-)amenities, Spatial equilibrium analysis, Quality of Life, Spatial autocorrelation

JEL classification: R13, R21, R23

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1 Introduction

The concept of the German social market economy not only aims at reducing social disadvantages among individuals, but also at creating „equivalent living conditions“ among regions [Benz, 1999].[1] As a main instrument of German regional policy, the Joint Task (*„Gemeinschaftsaufgabe“*) „Improvement of Regional Economic Structure“ is targeted at narrowing economic disparities among regions [Blume and Döring, 2009]. Major instruments of European regional policy, such as the European Regional Development Fund, are also designed to reduce the gap between economically leading and lagging areas [Mohl and Hagen, 2010, Eggert et al., 2007].

The alignment of structural funding towards economic indicators (such as GDP per capita or unemployment) yet might take too narrow a view, given that it is not automatically the case that the most productive regions are also the best places to live. Better access to highly-paid jobs and physical, social or cultural infrastructure has to be traded off against higher costs of housing, higher levels of congestion, pollution, crime, and other disadvantages of density. Even under a more comprehensive approach to measuring regional quality of life, the questions arise of how to appropriately weight and combine different indicators [Eckey et al., 2009, Uhde, 2008].

The starting point of the present paper is that regions, such as functional labor market areas, are characterized by specific combinations of housing costs, wage earnings, and non-market attributes which together affect total household utility. In order to comprehensively assess regional living conditions, these region-specific combinations must be analyzed within the integrated framework of cross-region spatial equilibrium. Popular regional quality-of-life rankings in Germany (and elsewhere) typically ignore that regional housing and labor markets closely interact. That is why analyzing inter-regional disparities in housing costs or wages alone is generally not sufficient for quality-of-life comparisons [Glaeser, 2008, Blomquist, 2008].

The paper extends existing research on the quality of life in Germany by providing new estimates for the role of non-market attributes in the determination of regional housing costs and wages. By using the hedonic pricing approach developed by Rosen [1979] and Roback [1982], the paper is related to the work of Buettner and Ebertz [2009], who investigate land price and wage differentials across Germany‘s (at then) 438 counties and cities. This study adds three important innovations: first, instead of using data for administrative areas, the estimation of implicit prices for non-market attributes draws on 141 functional labor market area delineations recently provided by Kosfeld and Werner [2012][2]. Testing for spatial autocorrelation in the estimated equations‘ residuals supports work by Rusche [2010], who suggests that using functional areas in regional quality-of-life research reduces the likelihood of parameter bias that is associated with the disregard of spatial interaction processes across administrative areas (such as commuting between the place of work, where wages are

[1] The concept of equivalent regional living conditions does not mean the elimination of any differences in regional quality of life, but rather generally equivalent public services and living standards. See Gunlicks [2005] for a detailed discussion.

[2] Referring to the methodology of Eckey et al. [2006], Kosfeld and Werner [2012] update the delineation of German functional labor market areas based on inter-county commuting patterns among counties and cities for the year of 2009.

usually observed, and the place of residence, where housing costs are observed).[3] Second, information on regional housing rents is used instead of regional prices for buildable land. Rents yield a more representative measure of housing costs for a country where nearly sixty per cent of households are tenants, and where annual construction is much less than one per cent of the existing housing stock. As we use rent data for new leases only, we circumvent problems of price stickiness in the market for in-place leases, which is related to rental housing market regulation and the presence of incomplete contracts in rental markets.[4] Third, the estimations are based on workers‘ wages instead of households‘ disposable incomes. This avoids possible distortion of the regional wage measure by non-labor earnings and public transfers. In order to further improve the consistency of the regional wage measure, workers‘ gross wages are corrected for tax and social security contributions to arrive at regional net wages.

According to our estimates in Section 5, the German labor market area with the highest regional quality-of-life estimate is Munich, followed by geographically adjacent areas of Weilheim-Schongau and Traunstein. Labor market areas in the post-industrial Ruhr-Area rank at the lower end. The estimates reveal that high quality-of-life areas according to our concept are predominantly located in the south and the north-east of Germany.

The structure of the paper is as follows. Section 2 reviews essential strands of the literature on regional quality of life, placing particular emphasis on the case of Germany. Estimable regional rent and wage equations are derived from spatial equilibrium theory in Section 3, while Section 4 serves to describe the data set. Empirical results on the capitalization of non-market attributes are discussed in Section 5. Based on a computation of the revealed total willingness to pay for a parsimonious set of regional (dis-)amenities, a comprehensive ranking of regional quality of life is presented that can be directly compared to findings of previous studies. Finally, Section 6 concludes.

2 Literature review

The hedonic approach to estimating regional quality of life has its roots in the seminal papers of Rosen [1979] and Roback [1982]. Building on the work of Rosen [1979], Roback [1982] sets up a structural spatial equilibrium framework which helps to assess the extent to which households and firms value certain non-market attributes on econometric grounds. Assuming that moving costs are negligible, optimizing households and firms will be attracted to areas where consumption and production is more appealing than in other places, given more attractive bundles of (dis-)amenities, wages, and housing costs. In long-run spatial equilibrium, region-specific combinations of wages, housing costs and (dis-)amenities must be equally attractive throughout all regions to prevent households and firms from further moves. A core insight of the Roback model is that people are willing to accept both lower wages *and* higher housing costs to get access to high-amenity/ low-disamenity places. Thus, a revealed preference

[3]The use of functional labor markets instead of administrative areas may be most beneficial in large cities and for the east of Germany, where a substantial share of workers typically commute from peripheral counties to the regional labor market core.

[4]In addition to using housing rents, alternative results are presented which draw upon a more comprehensive regional cost-of-living index.

approach aimed at deriving implicit prices for regional (dis-)amenities has to account for cross-regional differences in both housing costs *and* wages. It is important to note that within this structural framework, quality of life does not mean overall well-being or total utility, but rather the revealed value of the specific set of (dis-)amenities that households and firms associate with different regions [Blomquist, 2008].

A large number of studies rely upon the hedonic approach to assess quality-of-life differences among regions in several countries.[5] In their influential study, Blomquist et al. [1988] identify the impact of various (dis-)amenities on housing costs and wages, so as to quantify quality of life across various US metropolitan areas. They find strong support for quality-of-life relevance of regional climate and environmental quality (precipitation, humidity, heating degree days, sunshine, and air pollution), as well as of regional endowments with physical, social, and cultural infrastructure (violent crime, waste landfills, teacher-pupil ratio, etc.). Extending the study of Blomquist et al. [1988], Gyourko and Tracy [1991] test the relevance of fiscal conditions as a potential determinant of regional quality of life in addition to non-market attributes. Along with local taxes, they control for physical and cultural infrastructure, as well as for labor market access in a sample of 130 US cities. Their results indicate that, by manipulating tax schemes and public spending, city governments have much more control over local quality of life than previously thought.

More recent studies increasingly focus on the interlinkages between regional (dis-)amenities, population dynamics, and economic growth. Deller et al. [2001] show that predictable relationships between non-market attributes and local economic growth exist for rural counties in the US. Glaeser et al. [2001] demonstrate the importance of consumption amenities for quality of life among 19 metropolitan areas in the US, as well as for London and Paris. Following these authors, in particular cultural infrastructure such as restaurants, art museums, or movie theaters increase quality of life in a city and attract additional residents. Other studies indicate widening compensation differentials that reflect the rising demand for cultural amenities in developed countries [Florida, 2002, Costa and Kahn, 2003, Shapiro, 2006], as well as developing economies such as Russia [Berger et al., 2008], and China [Zheng et al., 2009].

In a series of recent papers, Albouy [2009, 2012], Albouy et al. [2013a] and Albouy et al. [2013b] provide estimates for differences in consumption and productivity amenities across US and Canadian cities, incorporating a number of innovative features such as inter-city differences in non-housing costs, non-labor income, intergovernmental transfers, federal taxes, and heterogeneity in household tastes. In comparison to previous studies, the authors claim that such adjusted quality-of-life measures do not tend to decrease with city size, more successfully predict how housing costs rise with wage levels, and correlate stronger with popular „livability“ rankings. Much in line with existing research, the papers still conclude that cities offering the highest quality-of-life levels are typically coastal, cultural, educated, and large.

Evidence on regional quality of life in Germany is rather limited. Buettner and Ebertz [2009] aim at determining the quality of life in 438 counties and cities based on implicit prices for several location traits, which they derive from cross-

[5] In view of the extensive literature, this section does not review existing research in depth. Comprehensive surveys of the field are provided by Gyourko et al. [1999] and Lambiri et al. [2007].

county land price and income regressions. Their analysis uses data from federal and regional statistical offices, as well as from the household survey „Perspektive Deutschland“, spanning the period 2001 to 2003.[6] While their explanatory variables yield high explanatory power for inter-county land price differences, self-reported household incomes turn out to be mostly insensitive to the included (dis-)amenities. Hence, departing from their original motivation, Buettner and Ebertz [2009] infer the revealed willingness to pay for each regional (dis-)amenity from the land price regression only. According to their results, high quality-of-life locations are predominantly located in southwestern Germany, as well as in the vicinity of the capital city of Berlin.

Rusche [2010] extends the work of Buettner and Ebertz [2009] by more deeply analyzing the spatial structure of regional quality of life. In a first step, the author aggregates the original quality-of-life estimates reported by Buettner and Ebertz [2009] to the level of functional labor market areas. In a second step, he statistically identifies spatial (dis-)similarities in regional quality-of-life estimates, using Explanatory Spatial Data Analysis (ESDA).[7] He discovers significant spatial autocorrelation in quality-of-life estimates among functional labor market areas, which he interprets as evidence for the crucial role of the spatial reference level in regional quality-of-life analysis. Following his argument, the reference level of administrative counties may be too narrow for two reasons. First, the use of county-level data precludes accounting for functional relationships between cities and their hinterlands.[8] Second, several measurement concepts in the study of Buettner and Ebertz [2009] may reflect disparities across functional regions instead of smaller-scaled administrative areas. As examples, Rusche mentions regional labor market conditions or alternative job opportunities.

In a recent working paper, Wrede [2012] combines a spatial equilibrium model with a matching unemployment model in order to investigate the role of spatial unemployment disparities for regional quality of life in Germany.[9] Using a sample of 326 western German counties and cities, he finds support for the compensation of higher regional unemployment through wage and rent differences, concluding that the effect of any (dis-)amenity on wages and unemployment rates are of opposite sign. While the study adds new insights on the impact of labor market risk on quality of life, the author acknowledges that counties are bad proxies especially for labor markets, which raises similar methodological problems as encountered by Buettner and Ebertz [2009]. The

[6]The included local attributes reflect information on leisure facilities, crime, accessibility, climate, industry emissions, local labor market conditions and job opportunities.

[7]It is important to note that Rusche [2010] does not calculate original quality-of-life values for the functional labor markets he investigates. Instead, the quality-of-life values used in his analysis are simply unweighted averages of the county-based original estimates by Buettner and Ebertz [2009], which are based on the capitalization of local (dis)amenities into local land prices.

[8]Indeed, Buettner and Ebertz [2009] suggest that core cities tend to show lower quality-of-life levels than their surrounding counties. To some extent, this result may represent spatial scale bias, given that at least some hinterland-related amenities, such as open spaces or water bodies, may easily be accessible for households by commuting.

[9]In a comparable study, Möller [2009] investigates the revealed willingness to pay for the inter-temporal value of employment by analyzing differences in building land prices across western German counties and cities within a spatial econometric framework. However, in comparison to Wrede [2012], he does not focus on the implications of simultaneous cross-regional differences in wages *together* with land rents for regional quality of life.

results of the present paper suggest that OLS estimates do not suffer from spatial autocorrelation when functional labor market areas are used to infer implicit prices for regional non-market attributes.

3 Theoretical framework

A straightforward way of modeling the capitalization of differences in regional endowments with non-market attributes into regional wages and costs of spatially fixed goods, most notably housing, is provided by Glaeser [2008]. Consider footlose households and firms with identical preferences and production functions that choose locations out of a given set of functional labor market areas. Each labor market area is endowed with a specific bundle of non-market attributes, considered as (dis-)amenities. The regional attributes can affect both overall household utility and total productivity of firms. Land is scarce, so that households and firms compete for high-amenity/ low-disamenity places.[10] For cross-region spatial equilibrium, regional prices of non-tradables and regional wages have to adjust until both household utility and firm production costs are equalized across labor market areas, such that workers and firms have no incentive to move.

Assuming tractable forms for the representative consumption and production functions, the structure of the model can be described as follows. Households earn a wage income w and receive utility from consuming a spatially fixed good, labelled H and rented at a price of p_H, and from consuming a tradable composite good, denoted X, sold at a fixed price of $p_X = 1$.[11] Both in the following theoretical analysis and the empirical application, we choose to approximate the region-specific cost of the spatially fixed good by the price of rental housing, which is certainly non-tradable. In the Appendix, we also report alternative results for a more broad measure of regional costs of living, which can be interpreted as a mixture of the regional costs for both tradable and non-tradable goods [Albouy, 2009, Albouy et al., 2013b].

In addition to the amount of the two types of goods consumed, household utility is also affected by regional non-market attributes, captured by an index θ. This index serves as a level parameter in the following household utility function:

$$u = \theta H^{\alpha} X^{1-\alpha} \tag{1}$$

where α represents the share of wage spent on the spatially fixed good, approximated by rental housing ($0 \leqslant \alpha \leqslant 1$). Maximizing utility with respect to the household budget constraint yields the indirect utility function:

$$v = \alpha^{\alpha}(1-\alpha)^{1-\alpha}\theta w p_H^{-\alpha} \tag{2}$$

It is assumed that households seek to minimize expenditures so as to attain the same level of utility as fixed utility in a „reservation region“, denoted $\overline{u}_R$:

$$v \equiv \overline{u}_R \tag{3}$$

[10] By assumption, the cost of interregional moving is zero, so that both consumers and firms are perfectly mobile across locations. We also adopt the standard assumptions that commuting *within* each labor market area is costless.

[11] Note that using the X good as numeraire is in line with the tendency to the law of one price for tradable goods.

From equation 3, it can be seen that if households in a given labor market area accept both higher housing costs *and* lower wages, analyzing differentials in housing costs alone will understate the true benefit of living in high cost of living locations.

Firms produce the tradable composite good using regional labor, N.[12] Each single firm is small relative to the market, hence w (the nominal wage rate paid to workers in the labor market) is exogenous to the single firm. Total productivity of firms is affected by region-specific productivity A, which enters the production function as a level parameter:

$$x = AN^{\beta} \tag{4}$$

where β $(0 < \beta < 1)$ is the production elasticity of labor. Cost minimizing behavior implies that each firm produces a certain share of total regional output, $\overline{X}_j$ (since the composite good is fully tradable, it need not be the case that the amount of X consumed in region j equals the regional production of X).

Optimizing behavior of workers and firms in the housing and labor market yields the following housing and labor demand functions at the region level, respectively:[13]

$$H^D = \alpha w N p_H^{-1} \tag{5}$$

$$N^D = \left(\beta^{-1} A^{-1} w\right)^{\frac{1}{\beta-1}} \tag{6}$$

Spatial equilibrium requires a combination of housing costs p_H, wage rates w, and workers N that clears both the regional housing and labor market simultaneously. Additionally, the combination must also apply for equation 3 to hold, i.e. household utility in any region must equal the reservation utility level of $\overline{u}_R$.

Rearranging the three equilibrium conditions, taking logs and defining $\log(\alpha) \equiv \kappa_1$, $\log(\beta) \equiv \kappa_2$ and $\alpha\log(\alpha) + (1-\alpha)\log(1-\alpha) - \log(\overline{u}_R) \equiv \kappa_3$ yields:

$$\log(p_H) = \log(w) + \log(N) - \log(\overline{H}) + \kappa_1 \tag{7}$$

$$\log(w) = \log(A) + (\beta - 1)\log(N) + \kappa_2 \tag{8}$$

$$\log(w) = \alpha\log(p_H) - \log(\theta) + \kappa_3 \tag{9}$$

After additional rearrangements and solving for p_H and w, respectively, one arrives at the following expressions for regional housing cost and wage differentials:

$$\log(p_H) = \eta_1 + \frac{\log(A) + (\beta-1)\log(\overline{H}) + \beta\log(\theta)}{1 - \beta + \alpha\beta} \tag{10}$$

$$\log(w) = \eta_2 + \frac{\alpha\log(A) + \alpha(\beta-1)\log(\overline{H}) + (\beta-1)\log(\theta)}{1 - \beta + \alpha\beta} \tag{11}$$

[12]For sake of simplicity, the model abstracts from capital as a production factor. By assumption, each worker supplies exactly one unit of labor, independent of the regional wage rate.

[13]In contrast to Glaeser [2008], we drop housing production and treat regional housing supply as exogenous but potentially affected by region-specific attributes.

where η_1, η_2 are parameters independent of A, θ, and $\overline{H}$.
Following equations 10 and 11, regional disparities in housing costs and wages are dependent on differences in θ and A, which proxy regional (dis-)amenity and productivity endowments, as well as on differences in the supply of housing, $\overline{H}$. Under feasible values for α and β, housing costs depend positively on A and θ, while negatively on $\overline{H}$. Wages depend positively on A and negatively on both θ and $\overline{H}$.

Since A and θ are not observable in practice, equations 10 and 11 do not yet allow to infer the contribution of specific regional attributes to regional quality of life empirically. To resolve this issue, the following functional relationships are assumed to hold between a vector of *observable* non-market attributes, $\boldsymbol{z}$, and the regional amenity index, productivity, and housing:

$$\log(\theta) = b_\theta + \boldsymbol{z'\gamma_\theta} + \mu_\theta, \tag{12}$$

$$\log(A) = b_A + \boldsymbol{z'\gamma_A} + \mu_A, \tag{13}$$

$$\log(\overline{H}) = b_{\overline{H}} + \boldsymbol{z'\gamma_{\overline{H}}} + \mu_{\overline{H}}. \tag{14}$$

where the vectors $\boldsymbol{\gamma_k}$ include coefficients reflecting the assocation between attribute z_i and regional (dis-)amenities, productivity, and housing.

Inserting 12, 13 and 14 into 10 and 11 yields a pair of equations which directly link regional housing costs and wages with observable region traits:

$$\log(p_H) = \kappa_{p_H} + z_i \frac{\gamma_{A,i} + (\beta - 1)\gamma_{\overline{H},i} + \beta\gamma_{\theta,i}}{1 - \beta + \alpha\beta} + \varepsilon_{p_H} \tag{15}$$

and

$$\log(w) = \kappa_w + z_i \frac{\alpha\beta\gamma_{A,i} + \alpha(\beta - 1)\gamma_{\overline{H},i} + (\beta - 1)\gamma_{\theta,i}}{1 - \beta + \alpha\beta} + \varepsilon_w \tag{16}$$

where z_i denotes a specific non-market attribute i; $\gamma_{.,i}$ denotes the respective association between attribute i and regional quality of life, productivity, and housing; κ_{p_H}, κ_w are constants, and $\varepsilon_{p_H}, \varepsilon_w$ are error terms with usual properties. Given that the structural parameters of equations 15 and 16 would not be identified with the data at hand and without appropriate instrumental variables, in Section 5 the following reduced-form regressions are estimated:

$$\log(p_{H,j}) = \kappa_{p_H} + \boldsymbol{z_i'\delta_k} + \boldsymbol{\tau_i'\lambda_l} + \varepsilon_{p_{H,j}} \tag{17}$$

$$\log(w_j) = \kappa_w + \boldsymbol{z_i'\varphi_k} + \boldsymbol{\chi_i'\psi_m} + \varepsilon_{w_j} \tag{18}$$

where the vectors $\boldsymbol{\delta_k}$ and $\boldsymbol{\varphi_k}$ include k regression coefficients reflecting the average marginal effect of non-market attribute z_i on regional housing costs and wages, while $\boldsymbol{\lambda_l}$ and $\boldsymbol{\psi_m}$ denote vectors of control variables that are discussed in the Data Section.

The coefficients gained from reduced-form regressions of housing costs and wages on a vector of region-specific non-market attributes can be used to assess the revealed marginal willingness to pay for a certain attribute. This follows from differentiating the indirect household utility function with respect to z_i, which yields that a statistical estimate for the implicit price of a given attribute equals its marginal effect on regional housing cost (or more broady, the cost of spatially fixed goods) weighted with α, the share of housing (or non-tradables) in total household consumption, less its marginal effect on regional wage:

$$\hat{f}_i = \alpha \frac{\mathrm{dlog}(p_H)}{\mathrm{d}z_i} - \frac{\mathrm{dlog}(w)}{\mathrm{d}z_i} = \alpha\hat{\delta}_i - \hat{\varphi}_i \tag{19}$$

Based on the logic of equation 19, a regional quality-of-life index is computed for each functional labor market area. This is reached by totalling over all attributes k the difference between the attribute endowment of region j and the attribute endowment of the nationally representative region $\overline{z}$, which scores precisely average in each index component. The estimated implicit prices $\hat{f}_i$ are used as weights:

$$RQoL_j = \sum_{i=1}^{k} \hat{f}_i \left(z_{ij} - \overline{z}_i\right) \tag{20}$$

The RQoL index reflects the premium paid for the specific bundle of non-market attributes in region j *in comparison to the sample average.* It is important to remember that regional differences in the index should not be interpreted as differences in total household utility. The index rather indicates whether the non-market (dis-)amenity endowment of a given region is preferred to the (dis-)amenity endowments of other regions within the country [Blomquist, 2008].

4 Data

Functional labor market areas define a spatial scope in which households both live *and* work. This is clearly appropriate for regional quality-of- life analysis, since the wage information in our data set generally refers to the establishment location, while housing costs are measured at the place of residence. The empirical analysis hence relies on a cross-sectional data set for 141 functional labor market areas as statistical units. Each labor market area is characterized by high levels of internal commuting and high levels of seclusion from adjacent areas, ensuring that only a small fraction of workers commutes from one area to another [Eckey et al., 2006, Kropp and Schwengler, 2011]. The functional labor market area delineations stem from Kosfeld and Werner [2012], who construct such areas by applying factor analysis with oblique Oblimin rotation to commute data for German counties and cities. As a critical commute distance, they use a car travel time between 45-60 minutes, depending on both the population size of the labor market core and the real wage differential between the core and the peripheral counties.

Table 1 reports descriptive statistics on the variables included in the econometric analysis.[14] Data on nominal monthly gross wages per employee were obtained from federal and regional employment statistics (*Erwerbstätigenrechnung des Bundes und der Länder*). Gross wages were corrected for wage tax

[14]Since the original information on all variables refers to the level of counties and cities, it was necessary to aggregate it to the level of 141 functional labor market areas. This was done by calculating weighted arithmetic means for each variable, using the population size of the counties and cities forming a functional labor market area as weighting factors.

and social security contributions to arrive at nominal net wages, applying the 2007 income tax and social security scheme. Data on nominal housing rents for new leases were obtained from a comprehensive database on regional housing prices and rents provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (*Bundesinstitut für Bau-, Stadt- und Raumforschung, BBSR*). The data reflect locally representative median listing rents of standard apartments advertized through internet platforms and newspapers [Sigismund, 2005, von der Lippe and Breuer, 2010]. In order to report alternative results that refer to a more broad measure of regional price disparities of non-tradables apart from housing, we use a regional cost-of-living index (which includes housing costs) provided by Kawka and Beisswenger [2009].[15]

The independent variables are separated into two groups: one of regional non-market attributes, and one of baseline covariates that expected to capture structural differences among the regions. The group of regional non-market attributes is divided into subgroups reflecting several quality-of-life relevant indicator categories.[16] The indicators reflect regional climate and environment, land use, as well as endowments with (quasi-)public goods and services. The data were obtained from different official sources and generally refer to 2007. The only exceptions are indicators reflecting the bargaining coverage ratio of firms and centrality, which refer to 2010 and 2012, respectively.[17]

A set of covariates is included to avoid that regional non-market attributes erroneously pick up the effects of structural differences among regions on housing rents and wages. First, regional population density is included to proxy for agglomeration effects. Because of increased housing scarcity and higher productivity levels in more densely populated areas, the density variable is expected to be linked positively to both rents and wages. The regional wage equation also includes the proportions of high and low qualified workers as percentages of the regional worker population, the proportions of gross value added earned in the primary and secondary sectors as percentages of total regional value added, the proportion of firms with more than 250 employees as a percentage of all firms registered in the region, and the collective bargaining coverage of firms (indicated by the proportion of firms with payment systems complying to sector or firm-level collective bargaining agreements) in the region. Along with population density, the housing rent equation comprises the proportion of students in regional universities and polytechnics as a percentage of total regional population. To account for unobserved institutional differences across the country, finally a set of dummy variables is included indicating the affiliation of each functional labor market area to the 16 German states.[18]

[15]The bivariate correlation between regional housing rents and the regional cost-of-living index is 0.61.

[16]At this stage, all tested regional attribute variables are reported, including those that did not have a significant statistical association with rents or wages in our analysis.

[17]Detailed information on variable descriptions and sources can be found in Tab. 7 in the Appendix.

[18]The omitted reference unit is the state of Northrhine Westfalia.

Table 1: Variable names and summary statistics

Variables	**Mean**	**Min.**	**Max.**
Dependent variables			
Median housing rent per month (EUR/sqm)	5.43	4.02	10.13
Average net wage (EUR/month)	1599.44	1337.51	1937.96
(Regional cost-of-living index)	(1.0519)	(0.9376)	(1.3262)
Independent variables			
A) Regional non-market attributes			
Climate and environment			
Hours of sunshine (abs.)	1702.00	1187.00	1985.00
Industry emissions per sqkm (abs.)	10.92	2.41	72.75
Tourist overnight stays per inh. (abs.)	5.36	1.01	33.27
Land use			
Proportion of water bodies (%)	2.11	0.40	9.09
Proportion of built-up area (%)	12.61	5.44	40.74
Proportion of agricultural area (%)	50.78	18.80	76.20
Proportion of forest area (%)	31.68	3.17	64.90
Proportion of open spaces (%)	2.83	0.40	10.35
Physical, social and cultural infrastructure			
Travel time to EU agglomeration centres (min.)	107.70	51.60	186.20
Travel time to nearest ICE railway station (min.)	28.99	8.80	63.80
Travel time to nearest highway (min.)	18.04	3.50	59.30
Travel time to nearest international airport (min.)	67.97	19.40	209.00
Art and entertainment offerings per 100k (abs.)	100.52	51.34	279.08
Childcare places per 100 childs (abs.)	19.12	4.23	54.83
Safety and health			
Criminal assaults per 100k (abs.)	596.98	327.15	1186.62
Road traffic casualties per 100k (abs.)	536.42	377.27	761.12
Registered doctors per 100k (abs.)	150.80	102.90	233.60
B) Baseline covariates			
Population density (abs.)	250.21	40.37	1906.42
Proportion of students (%)	2.33	0.00	15.64
Proportion of high qualified workers (%)	7.75	3.30	16.75
Proportion of low qualified workers %)	29.06	17.30	37.62
Proportion of primary sector production (%)	1.63	0.24	5.26
Proportion of secondary sector production (%)	32.68	12.89	58.89
Proportion of large firms (%)	0.29	0.07	0.46
Collective bargaining coverage of firms (%)	31.33	27.12	37.14

5 Empirical results

5.1 Basic correlation relationships

A stylized fact supporting the relevance of the spatial equilibrium approach for quality of life in German regions is the robust positive relationship between regional housing costs and net wage earnings (both in nominal terms), which is illustrated in Figure 1. The graph reveals some outliers among the 141 labor market areas which illustrate the concept of heterogeneous (dis-)amenity endowments: labor market areas characterized by combinations of disproportionally high housing costs relative to wage earnings should be endowed with comparatively high levels of consumption amenities, while the opposite holds true for regions with high wages relative to housing costs. Outliers above the linear fit hence indicate a trend to high non-market amenity regions, whereas outliers below indicate a trend to low non-market amenity regions. Two illustrative examples are the labor market areas of Munich and Wolfsburg, the sharpest outliers to the north and south, respectively.[19]

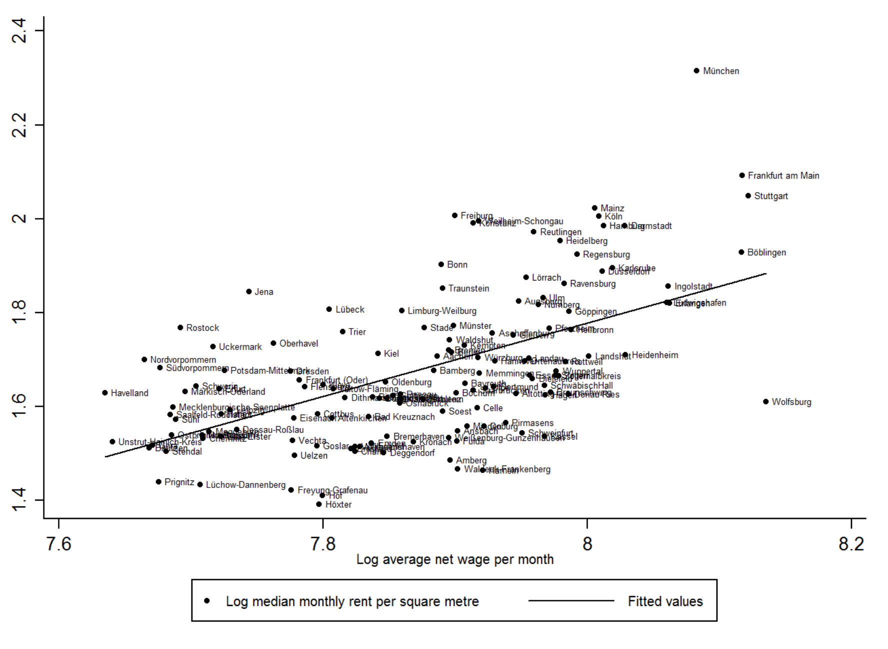

Figure 1: Housing costs and nominal wage earnings by functional labor market areas (141)

Another qualitative implication of spatial equilibrium is that labor market areas endowed with high amenity levels tend to be characterized by lower *real* wages, since high real wages are required for compensation of low amenity levels

[19] It should be noted that functional labor market areas in eastern Germany tend to lie above the linear fit. This indicates that the simple bivariate correlation neglects the impact of history, in the form of regional belongings to the former parts of eastern and western Germany, on regional wage earnings. However, it can be shown that the positive link between housing costs and wages still holds when both parts of the country are considered separately.

in less attractive places. To confront this hypothesis with empirical data for German labor market areas, average nominal wages are deflated by a regional price index including both non-housing goods *and* housing, following Kawka and Beisswenger [2009].[20] Figure 2 shows the link between the regional wage, now adjusted for non-housing costs of living *and* housing, and the proportion of water bodies as a percentage of regional area as an example of a utility-affecting consumption amenity. If large shares of water bodies yield utility to households (e.g., because of specific leisure activities related to water), then spatial equilibrium suggests a negative relationship between the two variables. The scatterplot suggests that households living in German labor market areas characterized by higher proportions of lakes, rivers, and seasides indeed forego a certain amount of real wage earnings. Caution is of course warranted, as the relationship might only be spurious due to unobserved variables correlated with regional proportions of water bodies.

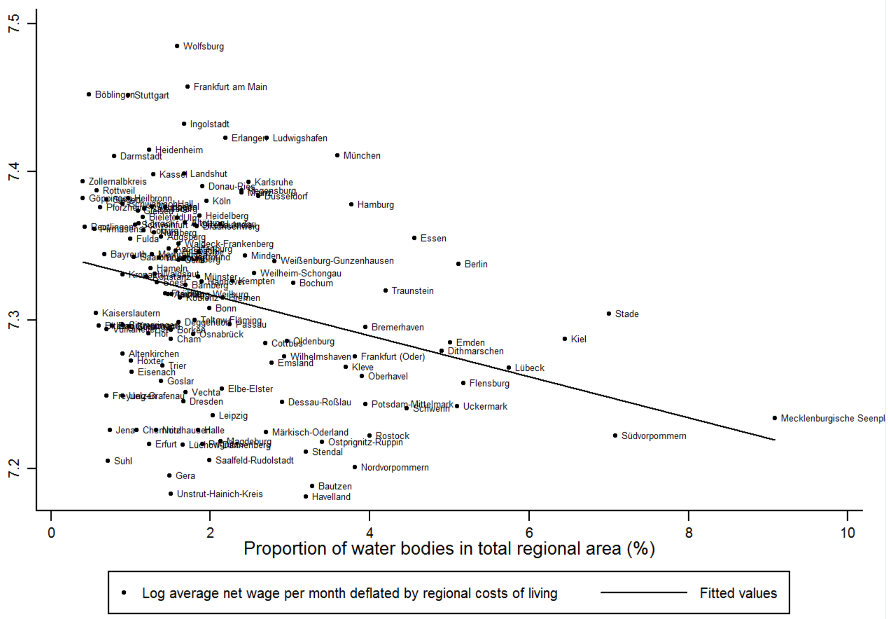

Figure 2: Real wage earnings and proportion of water bodies by functional labor market areas (141).

Finally, the spatial equilibrium concept sheds light on the links between the size and the density of a functional labor market area and its productivity. Figure 3 depicts the cross-regional correlation between regional wage (in nominal terms) and population density for the 141 labor market areas. The relationship is overwhelmingly positive, suggesting that workers in more densely populated labor market areas tend to be more productive. A very similar picture can be shown to exist for labor market area population size, indicating that German regional economies tend to be subject to pronounced returns to scale.

[20] Note that for the wage regressions, nominal net wages are used.

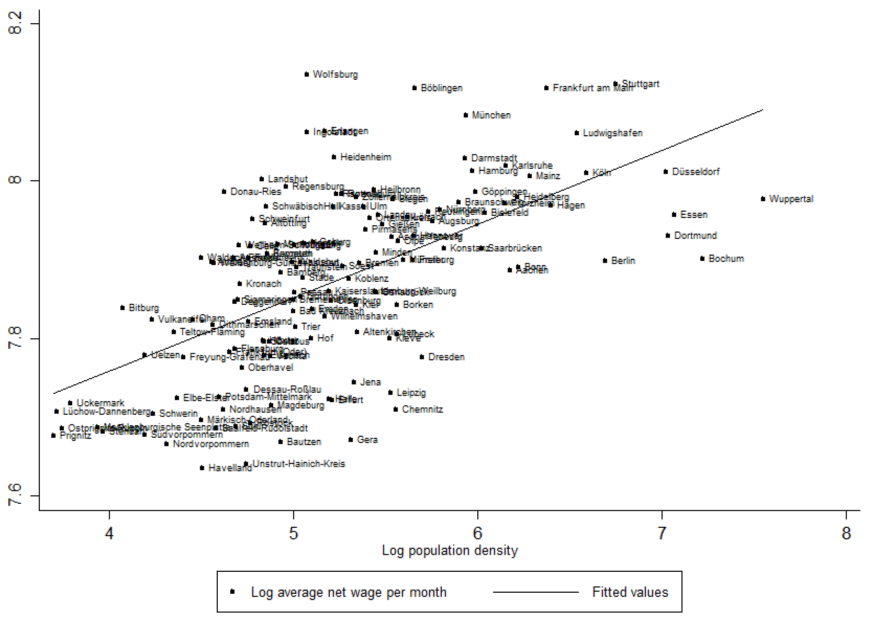

Figure 3: Nominal wage earnings and population density by functional labor market areas (141)

5.2 Regional rent and wage regressions

Empirical estimates for the capitalization of non-market attributes into regional housing cost and wage differentials were derived by ordinary least squares regression of equations 17 and 18, using Huber-White robust standard errors to correct for heteroscedasticity and clustering. Table 2 summarizes the regression results for a parsimonious specification, which includes eight of the overall tested 17 (dis-)amenity indicators.

According to R^2-values of 0.83 and 0.91, respectively, both equations have reasonably high levels of explanatory power. The majority of the included non-market attributes and covariates are found to be statistically significant. It is worth noting that, given just 141 regional observations, the degrees of freedom are relatively small for both equations, that is why the coefficient of determination may be slightly overestimated in both models. Moderate levels of collinearity are identified for some variables, most notably for population density and the proportion of built-up area.

To control for the potential presence of spatial autocorrelation in the ordinary least squares regressions, global Moran‘s I values are computed for the residuals of both equations. This is reached by using a row-standardized binary queen contiguity matrix, in which functional labor market areas are defined as neighbors if the direct distance between the regions‘ centroids is less than 65 km. This distance roughly corresponds to the commuting distance concept of Kosfeld and Werner [2012]and ensures that each region has at least one neighbor. From permutation tests it can be derived that the residuals‘ Morans I follows to be statistically indifferent from zero for both equations, so the null of

Table 2: Regression results for regional housing rent and wage equations (*,**,*** denote statistical significance at the 10%-, 5%- and 1%-level, respectively, t-statistics are calculated using robust standard errors).

	Log rent (15)			Log wage (16)		
Variables	**Coefficient**		**t-statistic**	**Coefficient**		**t-statistic**
Non-market (dis-)amenities						
Hours of sunshine	**0.00015**	***	2.13	0.00005		1.63
Industry emissions per sqkm	0.00234		1.64	**0.00200**	**	2.60
Proportion of water bodies	**0.01385**	*	1.77	0.00200		1.02
Proportion of built-up area	**-0.01103**	***	-3.44	0.00070		-0.58
Travel time to EU agglomeration centres	**-0.00108**	***	-2.84	**-0.00025**	*	-1.67
Art and entertainment offerings per 100k	**0.00238**	***	7.36	**0.00035**	**	2.46
Criminal assaults per 100k	**-0.00017**	***	-2.68	0.00002		0.72
Registered doctors per 100k	0.00048		1.22	**-0.00031**	*	-1.76
Baseline covariates						
Log population density	**0.11125**	***	3.66	-0.00428		-0.24
Proportion of students	**0.01209**	***	3.12			
Proportion of high qualified workers				**0.01056**	***	3.63
Proportion of low qualified workers				-0.00038		-0.27
Proportion of primary sector production				**-0.01582**	***	-2.72
Proportion of secondary sector production				**0.00256**	***	4.23
Proportion of large companies				0.04092		0.81
Collective bargaining coverage of firms				**0.00855**	*	1.85
State dummies						
Schleswig-Holstein	0.06803		1.44	-0.00597		-0.32
Hamburg	0.04910		1.17	**0.06664**	***	5.04
Lower Saxony	**0.05587**	**	2.03	**0.02175**	*	1.77
Bremen	0.06031		1.59	**0.04101**	**	2.04
Hesse	**0.07663**	**	1.85	**0.06300**	***	3.19
Rhineland-Palatinate	0.04937		1.40	0.01039		0.73
Baden-Wuerttemberg	**0.09021**	**	2.55	0.01806		1.13
Bavaria	**0.05765**	*	1.66	**0.02750**	*	1.66
Saarland	0.01519		0.26	0.01730		1.11
Berlin	**-0.37518**	***	-7.58	**-0.05295**	***	-2.96
Brandenburg	**0.11904**	***	3.39	-0.05022		-1.56
Mecklenburg-Western Pomerania	**0.17358**	***	3.23	-0.05061		-1.47
Saxony	**-0.11899**	***	-3.01	**-0.14736**	***	-5.47
Saxony-Anhalt	0.04602		1.09	**-0.06835**	**	-2.14
Thuringia	**0.06816**	**	1.97	**-0.09253**	**	-2.67
Regression diagnostics						
R^2	0.8341			0.9114		
Morans I of residuals	-0.0402			-0.0312		
SE of residuals	0.0715			0.0287		

no spatial autocorrelation cannot be rejected. Figures 5 and 6 in the Appendix illustrate the absence of spatial autocorrelation in the OLS residuals of both equations graphically.

Considering the included non-market attributes, there is empirical evidence for the capitalization of regional differences in annual sunshine, crime rates, centrality (measured by average travel times to EU agglomeration centres), area proportions of water bodies and built-up area, as well as endowments with art and entertainment offerings into regional housing rent differentials. Statistically significant wage effects are found for regional differences in industry emissions, travel times to EU agglomeration centres, art and entertainment offerings, as well as endowments with registered doctors per 100,000 inhabitants. The signs estimated on the attribute coefficients indicate that housing rents increase with pleasant climate, higher shares of water bodies, and a greater supply of art and entertainment offerings while being inversely related to higher proportions of built-up areas, higher travel times (lower levels of centrality), and higher crime rates. Wages are positively associated with industry emissions, centrality, and art and entertainment offerings, while being negatively linked to registered doctors density.

The signs estimated for the baseline covariates widely meet the theoretical expectations. The coefficients on population density and the share of students are positive and statistically significant in the housing rent equation, capturing demand effects in the market for rental housing. Population density turns out to be statistically insignificant in the regional wage equation, which suggests that agglomeration economies might be captured by the included non-market amenities, most specifically centrality. A higher qualified regional labor force, a higher share of manufacturing in regional production and a higher collective bargaining coverage of regional firms are all associated with higher average regional wages, while the opposite is true for higher shares of primary sector production. The proportions of large companies and low qualified workers turn out to be indifferent from zero at common significance levels. The coefficients estimated on the German state dummy variables indicate that workers in Berlin and some eastern German states receive significantly lower average wages than workers in various western German states. The evidence on state effects in the housing rent equation is mixed.

5.3 Empirical ranking of regional quality of life

In a next step, the estimated marginal effects of each regional attribute on regional housing costs and wages are used to compute the revealed overall marginal willingness to pay for each attribute. The calculation is based on equation 19, using a value of 0.30 for α, which corresponds to the average share of housing expenditure in total household budget in 2007.[21] In order to transform the overall marginal willingness to pay from a semi-elasticity to more transparent monetary values, the semi-elasticitiy point estimate is evaluated at the sample average net

[21] Alternative results reported in the Appendix, using a more broad measure of regional costs of living instead of housing rents, draw upon a value of 1.0 for α. It is important to note that, apart from the price of housing, it is not possible in practice to clearly distinguish between the prices of tradable and non-tradable goods, since even a haircut is a combined product of fixed and mobile inputs [Albouy, 2009, Albouy et al., 2013b]. In empirical application, assigning a weight of 100 per cent to the regional cost-of-living index is an interesting extreme case.

wage of 1,599 Euros per month. By multiplying the respective region-specific endowment of each (dis-)amenity with its full implicit price in monetary values, we then proceed with calculating a comprehensive index of regional quality of life (RQoL), following equation 20.

The first two columns of Table 3 report the revealed marginal willingness to pay that is associated with each non-market attribute as a combined semi-elasticity, and in Euros per month.[22] In line with expectations, sunshine duration, water bodies, registered doctors, as well as art and entertainment offerings are associated with a positive revealed willingness to pay and may hence be considered as quality-of-life increasing amenities. Crime, emissions, built-up areas, and a lack of centrality are associated with a negative revealed marginal willingness to pay and may thus be seen as quality-of-life decreasing disamenities.

In order to illustrate the relative contribution of each non-market attribute to the RQoL index, the remaining colums of Table 3 report the mean, the standard deviation, and the minimum and maximum values of each index component across the 141 functional labor market areas. For example, households living in the labor market area of the shortest sunshine duration (Emsland, Lower Saxony) are compensated about 60 Euros monthly in the housing and labor markets over households living in the region with the longest duration (Sigmaringen, Baden Wurttemberg), and roughly 40 Euros per month over those in the labor market area with the average duration. From combining these implicit prices with regional variations in (dis-)amenity endowments, it can be seen that differences in quality of life among German labor market areas appear to be mainly driven by differences in art and entertainment offerings and geographical conditions, while the other included (dis-)amenities tend to be relatively less important.

Tables 4 and 5 report the complete ranking of all 141 functional labor market areas by overall RQoL index values, based on housing rents and net wages as dependent variables.[23] A graphical illustration of the ranking is given by Figure 4. Among the top-ranked regions are the Munich labor market area and its surrouding regions, as well as the Berlin labor market area and surrounding regions in the northeast of Germany. Bottom-ranked regions with low RQoL index values are found especially for the post-industrial Ruhr area. According to the RQoL estimates, households living in the top-ranked region of the Munich labor market pay an implicit premium of about 160 Euros per month through housing and labor markets to access the amenity bundle of this region compared to the national average. At the other end of the spectrum, households in post-industrial labor market areas such as Wuppertal or Bochum receive a considerable monthly compensation through housing and labor markets for the comparatively disadvantageous amenity endowment compared to the nationally representative labor market area.

The above findings can be directly compared to those by Buettner and Ebertz [2009], which are based on land-price differences among German administrative counties and cities. To conduct this comparison, the county-specific rank values of the analysis by Buettner and Ebertz [2009] are aggregated to the level of 141 functional labor market areas, using total county population in 2007 as

[22]Alternative results drawing upon the regional cost-of-living index and net wages are reported in the Appendix.

[23]Alternative results drawing upon the regional cost-of-living index and net wages are reported in the Appendix. Spearman‘s rank correlation coefficient of the two rankings is 0.81.

Table 3: Estimated MWP and descriptive statistics on quality of life (monthly figures)

RQoL component	$\hat{f}_i$	$\hat{f}_i$ **in Euros**	**RQoL component values (Euros)**				
			Mean	S.E.	Minimum	Maximum	Top5 vs. average
Hours of sunshine	0.000045	0.07 Euros per additional hour	122.99	11.05	85.77	143.43	18.75
Industry emissions per sqkm	-0.002000	-3.20 Euros per additional ton	-34.92	27.74	-232.69	-7.70	26.72
Proportion of water bodies	0.004155	6.64 Euros per additional percentage point	13.99	9.81	2.66	60.38	33.00
Proportion of built-up area	-0.003308	-5.29 Euros per additional percentage point	-66.65	30.39	-215.48	-28.77	35.56
Travel time to agglomeration centres	-0.000078	-0.13 Euros per additional minute	-13.49	3.40	-23.33	-6.46	6.34
Art and entertainment offerings per 100k	0.000362	0.58 Euros per additional firm	58.24	19.52	29.75	161.71	77.56
Criminal assaults per 100k	-0.000051	-0.08 Euros per additional incident	-48.44	12.63	-96.28	-26.54	19.33
Registered doctors per 100k	0.000310	0.50 Euros per additional doctor	74.75	12.29	51.02	115.81	34.22

Table 4: Ranking of 141 German functional labor markets according to Regional Quality of Life Index

Position	Functional labor market	RQoL	Position	Functional labor market	RQoL
1	Munich	157.47	41	Heidelberg	23.42
2	Weilheim-Schongau	134.74	42	Limburg-Weilburg	23.05
3	Traunstein	97.06	43	Deggendorf	22.67
4	Mecklenburg Lake District	94.07	44	Elbe-Elster	22.27
5	Kempten	72.69	45	Jena	21.69
6	South Pomerania	65.97	46	Schwaebisch Hall	21.59
7	Berlin	62.84	47	Heidenheim	21.32
8	Freiburg	61.78	48	Ortenaukreis	20.69
9	Rostock	57.34	49	Bitburg	19.95
10	Wurzburg	56.55	50	Unstrut-Hainich	19.89
11	Waldshut	53.92	51	Upper Havel	19.50
12	Frankfurt (Oder)	53.86	52	Bayreuth	19.35
13	Potsdam-Mark	52.15	53	Memmingen	19.09
14	Uckermark	46.08	54	Magdeburg	18.13
15	Ostprignitz-Ruppin	45.24	55	Ingolstadt	17.55
16	Leipzig	43.42	56	Teltow-Flaming	17.48
17	Flensburg	39.17	57	Stendal	16.88
18	Regensburg	38.91	58	Luchow-Dannenberg	16.24
19	Schwerin	37.82	59	Waldeck-Frankenberg	15.70
20	Dithmarschen	37.53	60	Gottingen	15.60
21	Altotting	36.99	61	Bonn	15.49
22	Dresden	34.78	62	Erfurt	14.25
23	Kiel	34.66	63	Ulm	14.11
24	Amberg	34.64	64	Dessau	14.00
25	Hamburg	34.12	65	White Castle-Gunzenhausen	13.45
26	Bamberg	33.75	66	Reutlingen	12.50
27	North Western Pomerania	30.77	67	Cham	12.29
28	Markisch-country	29.68	68	Freyung-Grafenau	12.19
29	Ravensburg	29.35	69	Cologne	11.13
30	Passau	28.30	70	Constance	10.78
31	Cottbus	28.04	71	Prignitz	9.83
32	Uelzen	25.87	72	Augsburg	9.48
33	Landshut	25.62	73	Erlangen	9.06
34	Stade	25.18	74	Aschaffenburg	8.64
35	Havel country	25.11	75	Saalfeld-Rudolstadt	8.55
36	Lubeck	24.81	76	Ansbach	7.84
37	Bautzen	24.52	77	Darmstadt	7.83
38	Eifel	24.46	78	Fulda	7.00
39	Sigmaringen	24.25	79	Landau	6.62
40	Suhl	24.21	80	Schweinfurt	6.56

Table 5: Ranking of 141 German functional labor markets according to Regional Quality of Life Index (ctd.)

Position	Functional labor market	RQoL	Position	Functional labor market	RQoL
81	Bad Kreuznach	6.45	112	Coburg	-16.32
82	Trier	3.71	113	Soest	-19.80
83	Oldenburg	3.30	114	Osnabruck	-21.84
84	Donau-Ries	3.27	115	Goppingen	-21.99
85	Nordhausen	2.90	116	Wilhelmshaven	-22.26
86	Kassel	2.16	117	Hoxter	-22.89
87	Eisenach	1.19	118	Hamelin	-24.19
88	Celle	0.44	119	Emden	-29.00
89	Goslar	-0.30	120	Minden	-31.38
90	Nuremberg	-0.31	121	Wolfsburg	-33.95
91	Mainz	-0.39	122	Kleve	-36.69
92	Hall	-0.53	123	Pforzheim	-40.50
93	Zollernalbkreis	-1.00	124	Altenkirchen	-48.24
94	Rottweil	-1.30	125	Emsland	-51.32
95	Kronach	-1.38	126	Brunswick	-55.82
96	Karlsruhe	-1.80	127	Aachen	-56.95
97	Hof	-2.56	128	Olpe	-57.12
98	Lurrach	-2.79	129	Siegen	-61.64
99	Frankfurt (Main)	-3.24	130	Borken	-62.31
100	Kaiserslautern	-3.56	131	Vechta	-67.08
101	Pirmasens	-4.30	132	Saarbrucken	-72.50
102	Bremerhaven	-4.48	133	Bielefeld	-72.57
103	Koblenz	-5.97	134	Ludwigshafen	-102.84
104	Boblingen	-7.65	135	Stuttgart	-119.56
105	Chemnitz	-8.14	136	Hagen	-131.30
106	Hanover	-9.08	137	Dusseldorf	-164.06
107	Gera	-9.41	138	Essen	-172.95
108	Bremen	-9.59	139	Dortmund	-201.99
109	Giessen	-10.83	140	Bochum	-227.86
110	Heilbronn	-14.06	141	Wuppertal	-350.53
111	Munster	-14.68			

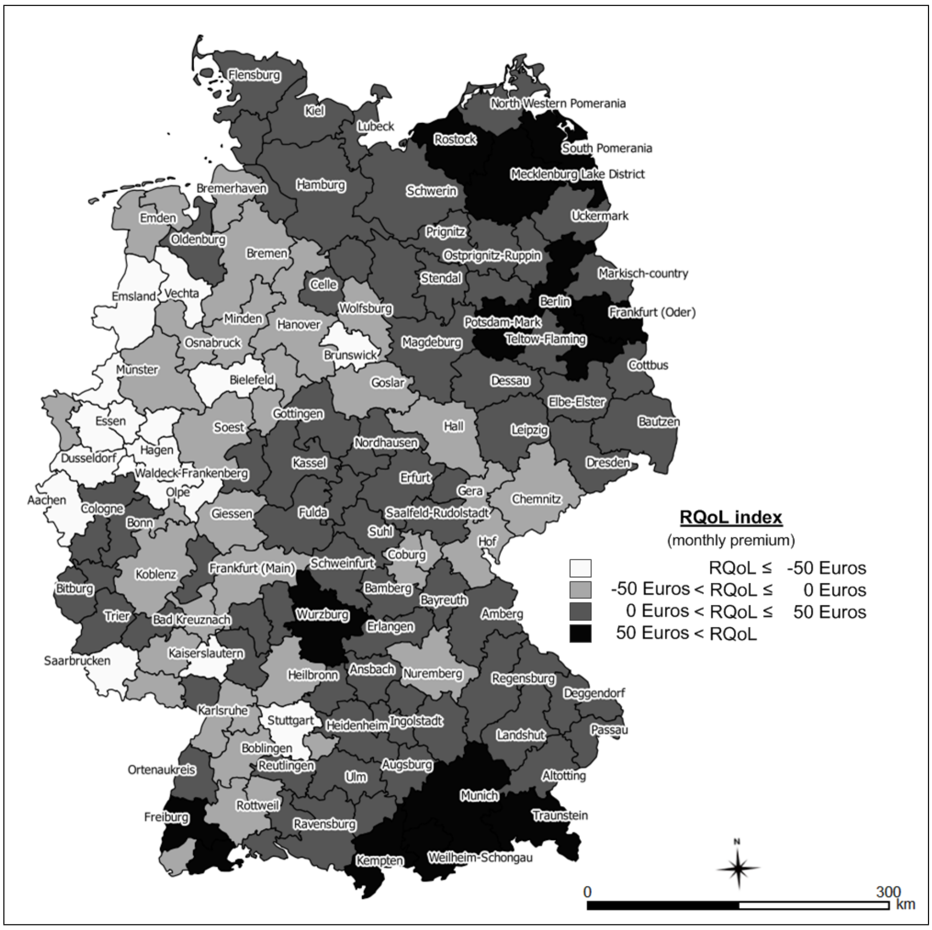

Figure 4: Quality of life in 141 German functional labor market areas according to housing rent and nominal net wage equation.

relative weights. Using Spearman‘s rank correlation coefficient, we measure a rank correlation of 0.55 between the ranks derived by Buettner and Ebertz [2009] and ours for eastern German regions, whereas for western German regions the rank correlation is only 0.3. If the alternative results using the regional cost-of-living index instead of housing rents is used, the respective rank correlations change to 0.5 and 0.6.

5.4 Regional quality of life and internal migration

In order to infer on the relevance and plausibility of the empirical results, we additionally test whether inter-regional differences in the non-market attributes identified in the prior analysis can statistically explain internal migration among the analyzed functional labor market areas. Existing research on regional migration flows in Germany has much focused on the role of regional wage and unemployment disparities (for a recent contribution, see Alecke et al. [2010]). Much less is known about the role of regional disparities in non-market (dis-)amenities, which certainly also affect utility-maximizing migration decisions.

Results for OLS regressions of regional net migration rates on the eight (dis-)amenity indicators and an eastern Germany dummy variable are reported in Table 6 for total population, as well as for four specific age groups. Except only two attributes (industry emissions and built-up areas), the included variables help to statistically explain regional net migration rates in several age groups. The estimated signs are generally in line with the estimated revealed willingness to pay for the selected attributes.[24] While these results are only temptative, further research may more deeply investigate these interesting interdependencies. Under continuous demographic ageing and further decreases in communication costs, it seems plausible that consumer amenities, as well as first-nature geography variables (such as pleasant climate), will tend to gain importance for German internal migration in the upcoming years.

6 Conclusion

While information on incomes, employment, and other economic and social indicators is readily available for German regions, this is much less the case for market-based valuations of regional non-market attributes that affect households‘ total utility. In order to close this gap, this paper concentrated on estimating a comprehensive regional quality of life index for German functional labor market areas. In line with the tradition of regional quality of life research, the analysis based on the assumption that regional non-market (dis-)amenities affect both household utility and firm productivity, such that the capitalization of these attributes into regional housing costs and wages should be jointly considered in a structural framework.

In line with spatial equilibrium theory, we find that regional endowments with non-market attributes simultaneously capitalize into regional housing cost

[24] Registered doctors yet carries an unexpected negative sign for migrants aged 30-50 years and those aged 50-65 years, which may to some extent be explained by missing relevant variables. Moran‘s I indicates that spatial autocorrelation is present in the 30-50 years regression, which may be explained by the specific spatial scope of migration decisions of „family migrants“.

Table 6: Regional net migration and non-market (dis-)amenities (*,**,*** denote statistical significance at the 10%-, 5%- and 1%-level, respectively, t-statistics are calculated using robust standard errors). The dependent variable is the net migration rate in 2007.

	All age groups			**18-30 years**			**31-50 years**			**51-65 years**			**older than 65 years**		
	Coefficient		**t-statistic**	Coefficient		**t-statistic**	Coefficient		**t-statistic**	Coefficient		**t-statistic**	Coefficient		**t-statistic**
Hours of sunshine	**0.00049**	***	2.67	0.00105		1.59	**0.00065**	***	3.19	0.00021		1.58	**0.00016**	*	1.76
Industry emissions per sqkm	-0.00161		-0.38	-0.00642		-0.27	0.00329		0.43	-0.00268		-0.66	-0.00468		-1.36
Proportion of water bodies	0.03573		1.25	-0.03062		-0.37	**0.06321**	**	2.20	**0.05128**	***	2.61	**0.04154**	***	2.58
Proportion of build-up area	0.00130		0,17	0.04787		1.55	-0.00993		-0.94	-0.00729		-1.23	-0.00320		-0.65
Travel time to EU aggolmeration centres	**-0.00178**	*	-1.71	**-0.00810**	**	-2.00	-0.00177		-1.43	0.00112		1.43	-0.00027		-0.45
Art and entertainment companies per 100k	**0.00524**	***	4.46	**0.01695**	***	4.64	**0.00572**	***	4.54	0.00089		1.01	0.00086		1.26
Criminal assaults per 100k	-0.00014		-0.76	-0.00032		-0.47	-0.00018		-0.87	0.00010		0.74	**-0.00018**	*	-1.73
Registered doctors per 100k	-0.00044		-0.24	**0.02680**	***	5.47	**-0.00777**	***	-3.64	**-0.00312**	**	-1.98	-0.00116		-1.11
Eastern Germany dummy	**-0.37136**	***	-4.60	**-1.38010**	***	-4.88	**-0.26302**	***	-2.92	**-0.19186**	***	-3.75	-0.05623		-1.28
Regression diagnostics															
R^2	0.5087			0.7351			0.3316			0.2923			0.2280		
Moran I residuals	0.0418			-0.0870			**0.2058**	***		0.0381			-0.0392		
Residual Standard Error	0.2916			0.9982			0.3166			0.2129			0.1717		

and wage differentials. While earlier findings of (dis-)amenity capitalization in the housing market is confirmed, the finding of significant (dis-)amenity wage effects contrasts with the findings of Buettner and Ebertz [2009], who use self-reported individual income data and control for workers‘ characteristics but cannot identify any (dis-)amenity effects on incomes. While unobserved regional heterogeneity of labor may explain these different findings, controlling for structural productivity and institutional differences between the functional labor market areas makes us confident that the capitalization of (dis-)amenities into regional wage differentials is not spurious. Once adequate individual property data for Germany becomes available, it may be worth to apply the theoretical framework to micro data at both regional housing and labor markets.

The empirical evidence of this paper corroborates previous findings of pronounced differences in quality-of-life across German areas. Only a part of these quality-of-life differences is associated with differences in public services provision by local or regional authorities. Along with first-nature geography variables, such as annual sunshine duration or the presence of water bodies, the structure of the regional quality-of-life index estimated in this paper is substantially influenced by regional levels of art and entertainment offerings. This tends to underline the relevance of consumer amenities for an area‘s competitiveness that has been underscored by Glaeser et al. [2001], Gottlieb and Glaeser [2006], and also more recently for Germany by Buettner and Janeba [2013] and Arntz [2010]. Finally, the absence of spatial autocorrelation in ordinary least squares residuals suggests that the use of functional labor market areas is methodologically appropriate in the context of regional quality of life research.

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Appendix

Table 7: Data descriptions and sources

Variable	Definition	Source
Housing rent	Median housing rent for standard apartments in Euros per square metre and month	BBSR
Wage earnings	Monthly net wage per worker adjusted for taxes and social security contributions	Erwerbstätigenrechnung
Regional cost of living	Regional cost-of-living index (including housing costs)	BBSR
Hours of sunshine	Annual sunshine time in hours	Deutscher Wetterdienst
Industry emissions	Aggregate emission of CH4, NOx and SO2 particles by 27 industries in tons per square kilometre	Federal statistical office
Tourist overnight stays	Tourist overnight stays per inhabitant	INKAR 2010
Proportion of water bodies	Water bodies as a percentage of total area	regionalstatistik.de
Proportion of built-up area	Area devoted to settlement, traffic and related uses as a percentage of total area	regionalstatistik.de
Proportion of agricultural area	Agricultural area as a percentage of total area	regionalstatistik.de
Proportion of forest area	Forest area as a percentage of total area	regionalstatistik.de
Proportion of open spaces	Open spaces as a percentage of total area	regionalstatistik.de
Travel time to agglomeration centres	Average travel time to 41 EU agglomeration centres in minutes	BBSR Erreichbarkeitsmodell
Travel time to ICE railway station	Average travel time to nearest ICE-railway station in minutes	BBSR Erreichbarkeitsmodell
Travel time to highway	Average travel time to nearest public highway	BBSR Erreichbarkeitsmodell
Travel time to airport	Average travel time to nearest international airport in minutes	BBSR Erreichbarkeitsmodell
Art and entertainment offerings per 100k	Firms classified as active in the art and entertainment industry per 100,000 inhabitants	regionalstatistik.de
Childcare places per 100 childs	Number of children (under 3 years) visiting a day-childcare centre	INKAR 2010
Criminal assaults per 100k	Registered cases of criminal assaults per 100,000 inhabitants	Kriminalstatistik
Road traffic casualties per 100k	Registered road traffic casualties per 100,000 inhabitants	INKAR 2010
Registered doctors per 100k	Registered doctors per 100,000 inhabitants	INKAR 2010
Population density	Total population per square kilometre	regionalstatistik.de
Proportion of students	Students as a percentage of total regional population	regionalstatistik.de
Proportion of high-qualified workers	Employees with at least one university or college degree as a percentage of all employees	INKAR 2010
Proportion of low-qualified workers	Untrained employees as a percentage of all employees	INKAR 2010
Proportion of primary sector production	Primary sector production as a percentage of total gross value added	regionalstatistik.de
Proportion of secondary sector production	Secondary sector production as a percentage of total gross value added	regionalstatistik.de
Proportion of large companies	Companies with at least 250 employees as a percentage of all companies	regionalstatistik.de
Collective bargaining coverage of firms	Firms complying to sector or firm level collective bargaining agreements	Verdienststrukturerhebung

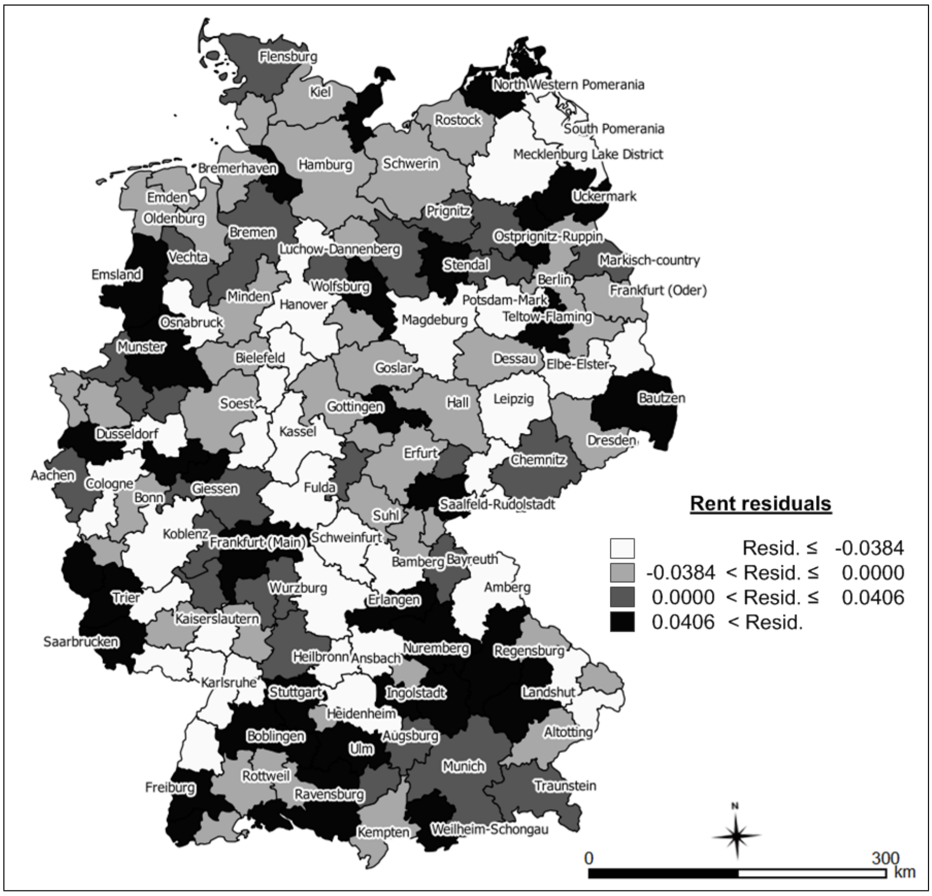

Figure 5: Geographic distribution of OLS residuals for housing rent equation

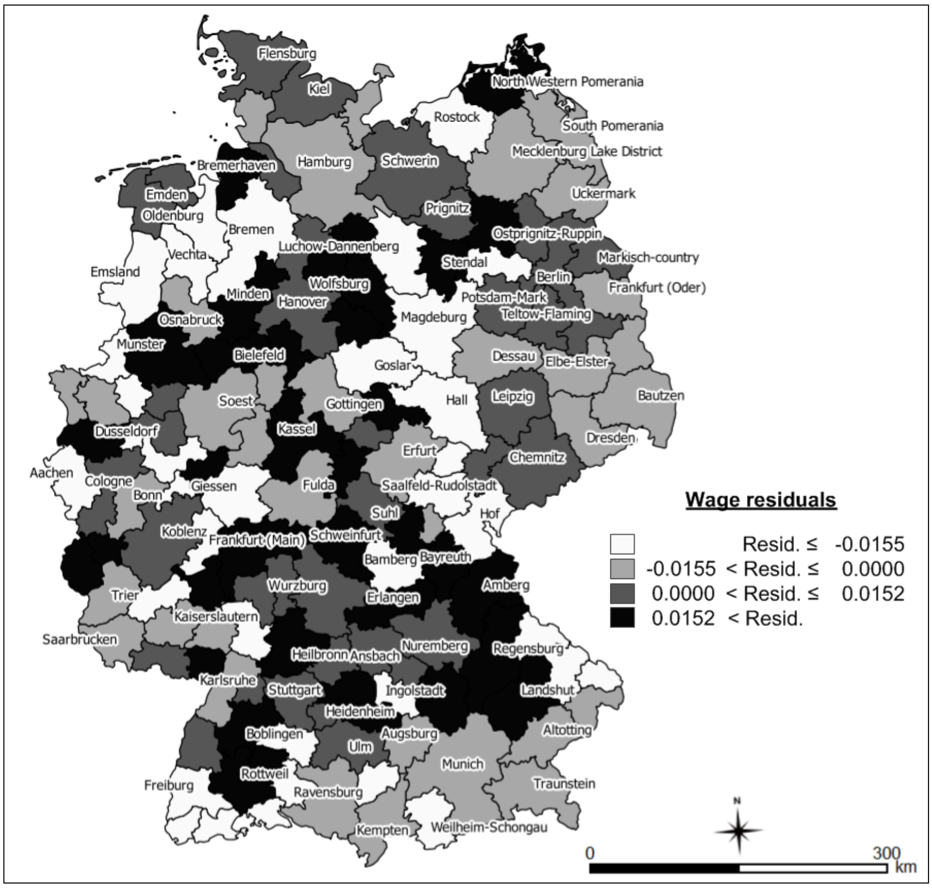

Figure 6: Geographic distribution of OLS residuals for nominal net wage equation

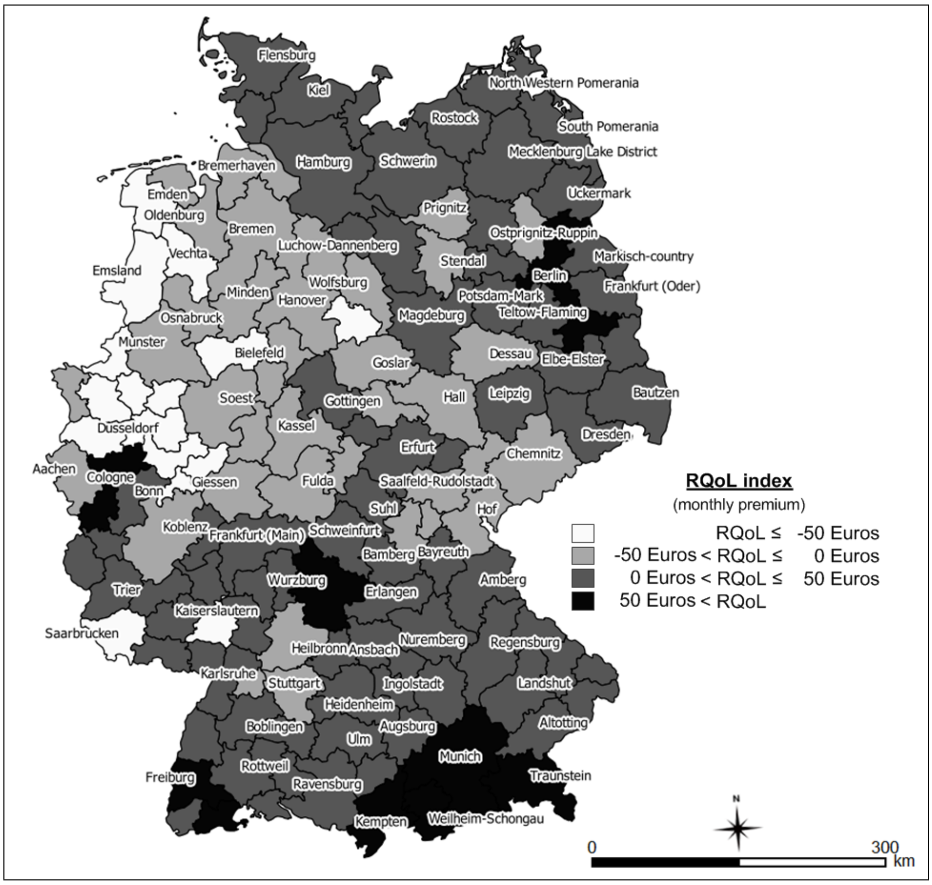

Figure 7: Alternative results for quality of life in 141 German functional labor market areas according to regional cost-of-living index and nominal net wage estimations

Table 8: Alternative regression results using regional costs of living together with wages (*,**,*** denote statistical significance at the 10%-, 5%- and 1%-level, respectively, t-statistics are calculated using robust standard errors).

	Log COL-index			Log wage		
Variables	**Coefficient**		**t-statistic**	**Coefficient**		**t-statistic**
Non-market (dis-)amenities						
Hours of sunshine	**0.00006**	***	2.65	0.00005		1.63
Industry emissions per sqkm	**0.00108**	**	2.18	**0.00200**	**	2.60
Proportion of water bodies	0.01385		1.77	0.00200		1.02
Proportion of built-up area	**-0.00319**	***	-3.44	0.00070		-0.58
Travel time to EU agglomeration centres	**-0.00031**	***	-2.62	**-0.00025**	*	-1.67
Art and entertainment offerings per 100k	**0.00081**	***	6.38	**0.00035**	**	2.46
Criminal assaults per 100k	**-0.00004**	**	-2.31	0.00002		0.72
Registered doctors per 100k	0.00004		0.31	**-0.00031**	*	-1.76
Baseline covariates						
Log population density	**0.04259**	***	4.00	-0.00428		-0.24
Proportion of students	**0.00227**	*	1.87			
Proportion of high qualified workers				**0.01056**	***	3.63
Proportion of low qualified workers				-0.00038		-0.27
Proportion of primary sector production				**-0.01582**	***	-2.72
Proportion of secondary sector production				**0.00256**	***	4.23
Proportion of large companies				0.04092		0.81
Collective bargaining coverage of firms				**0.00855**	*	1.85
State dummies						
Schleswig-Holstein	0.01950		1.22	-0.00597		-0.32
Hamburg	**0.02811**		1.78	**0.06664**	***	5.04
Lower Saxony	**0.02930**	***	3.30	**0.02175**	*	1.77
Bremen	**0.03648**	***	3.77	**0.04101**	**	2.04
Hesse	**0.02317**	*	1.83	**0.06300**	***	3.19
Rhineland-Palatinate	0.00867		0.77	0.01039		0.73
Baden-Wuerttemberg	**0.03207**	***	2.77	0.01806		1.13
Bavaria	0.00876		0.76	**0.02750**	*	1.66
Saarland	-0.00387		-0.25	0.01730		1.11
Berlin	**-0.12472**	***	-6.65	**-0.05295**	***	-2.96
Brandenburg	-0.01444		-1.19	-0.05022		-1.56
Mecklenburg-Western Pomerania	0.00337		-0.20	-0.05061		-1.47
Saxony	**-0.08072**	***	-5.96	**-0.14736**	***	-5.47
Saxony-Anhalt	**-0.02206**	*	-1.83	**-0.06835**	**	-2.14
Thuringia	**-0.02137**	**	-2.02	**-0.09253**	**	-2.67
Regression diagnostics						
R^2	0.8937			0.9114		
Morans I of residuals	-0.0458			-0.0312		
SE of residuals	0.0227			0.0287		

Table 9: Alternative results for MWP and descriptive statistics on quality of life (monthly figures) using regional costs of living together with wages

RQoL component	$\hat{f}_i$	$\hat{f}_i$ **in Euros**	**RQoL component values (Euros)**				
			Mean	S.E.	Minimum	Maximum	Top5 vs. average
Hours of sunshine	0.000064	0.10 Euros per additional hour	173.20	15.56	120.78	201.77	26.40
Industry emissions per sqkm	-0.000923	-1.48 Euros per additional ton	-16.11	12.79	-107.33	-3.55	12.32
Proportion of built-up area	-0.003189	-5.10 Euros per additional percentage point	-64.26	29.30	-207.76	-27.74	34.28
Travel time to agglomeration centres	-0.000064	-0.10 Euros per additional minute	-10.98	2.77	-18.98	-5.26	5.16
Art and entertainment offerings per 100k	0.000455	0.73 Euros per additional firm	73.09	24.50	37.33	202.93	97.33
Criminal assaults per 100k	-0.000043	-0.07 Euros per additional incident	-40.70	10.61	-80.89	-22.30	16.24
Registered doctors per 100k	0.000310	0.50 Euros per additional doctor	74.75	12.29	51.02	115.81	34.22