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## Wages, Rents, Unemployment, and the Quality of Life

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# Wages, Rents, Unemployment, and the Quality of Life

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## Abstract

Combining a spatial equilibrium model with a search-matching unemployment model, this paper analyzes the willingness to pay for regional amenities and the regional quality of life when wages, rents, and unemployment risk compensate for local amenities and disamenities. The results are compared with those obtained from the Rosen-Roback approach. Furthermore, the paper shows that the wage curve is negatively sloped for quasi-linear utility. Specifically, the wage rate increases and the unemployment ratio decreases in response to an increase in the amenity level if the amenity is marginally more beneficial to producers than to consumers. As an illustration of the unemployment-adjusted quality-of-life measure, the quality of life in West German counties is estimated.

*JEL Classification:* R12, R13, R14, H73, J61, J64.

*Keywords:* Quality of life, residential mobility, unemployment, job search, matching.

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# 1 Introduction

Although the total population growth has been declining in many OECD countries, the demographic burden is not uniformly distributed among or within countries. Although populations have declined in some regions (such as East Germany, southern Italy, western Spain, northern Sweden), during the same period, other regions have experienced enormous population increases (such as the western U.S., eastern Spain, southern Germany, northern Italy, and southern Sweden). Generally, the populations of these countries are geographically mobile, although they are more mobile in some countries, such as the U.S., than in others. The willingness of households and firms to migrate induces competition among cities, counties, and states for mobile workers and firms. Migration is driven by differences in labor market conditions, land markets, natural amenities, and publicly provided goods. By considering price differences, households and firms move to locations in which they expect to encounter better living and working conditions.

The value that households attach to local amenities can be calculated from the wages and prices of non-tradable goods, especially land prices, by employing a neoclassical model with perfect competition and perfect geographical household and firm mobility, (see Rosen, 1979; Roback, 1982; Blomquist, Berger, and Hoehn, 1988; Blomquist, 2006). The quality of life in a certain location is measured by the amount of labor income minus expenditures for the non-tradable goods that workers are willing to forego for the opportunity to live in the respective region. Since the 1980s, the theoretical model and empirical strategies have been modified to account more consistently for local public finance (Gyourko and Tracy, 1991), federal taxation (Albouy, 2009), differences between home values and rents (Winters, 2010), and migration costs (Bayer, Keohane, and Timmins, 2009). Gabriel and Rosenthal (2004) and Chen and Rosenthal (2008) calculated a quality-of-business-environment index and used location-specific fixed effects rather than a long list of local amenities. Other researchers have estimated regional utility levels based on interregional migration data (see Greenwood, Hunt, Rickman, and Treyz, 1991; Wall, 2001; Douglas and Wall, 1993, 2000; Nakajima and Tabuchi, 2011).

In the underlying neoclassical spatial-equilibrium full-employment model, only price differences compensate households for differences in local amenities. To account for un-

employment in empirical models, unemployment must be considered as a local disamenity. Unemployment either is a right-hand variable in price regressions or is indirectly considered through location-specific fixed effects. However, unemployment cannot be considered exogenous because it results from individual decisions, institutions, and market forces. Furthermore, wages, land prices, and employment are determined simultaneously. Given the presence of imperfect labor markets, unemployment risk must be added to local wages and local prices as a variable to compensate households for differences in location-specific resources.

Hence, the purpose of this paper is to develop a general equilibrium model with unemployment that can be used to calculate the willingness of households to pay for the opportunity to live in attractive regions. More specifically, a search-matching model of unemployment (see, e.g., Mortensen and Pissarides, 1994; Diamond, 1984; Pissarides, 2000; Petrongolo and Pissarides, 2001) will be incorporated into a spatial equilibrium model with local amenities. In contrast with Lee (2008), who investigates rural-urban migration, and Zenou (2009), who models continuous space in an urban-economics framework, we consider one small region and focus on local amenities.<sup>1</sup> From the steady-state equilibrium conditions, we determine the effect of changes in the level of any amenity with respect to rents, wages, and unemployment rates. By referring to the present value of the expected income stream of perfectly mobile unemployed individuals, we calculate a quality-of-life measure. Quality of life is determined as the land rent that mobile unemployed individuals are willing to pay for the opportunity to live in the respective region – adjusted for wages and unemployment risk.

Using German county data, we calculate the quality of life in West German counties and compare our results with the results that were obtained using the standard approach, in which unemployment is not considered an endogenous variable. We also use these data to test several predictions from the underlying model.

The paper offers several important contributions: first, by merging a spatial mobility model with a search-matching model, this research develops a general equilibrium model with unemployment and geographic mobility that can be used to determine regional qual-

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<sup>1</sup>By now Kline and Moretti (2013) uses a similar model to analyze place based employment policies.

ity of life. As such, the paper overcomes the inconsistency of the standard quality-of-life approach that assumes perfect labor markets in the theoretical model but uses data on apparently involuntary unemployment in the empirical application and considers unemployment an exogenous parameter. Second, for quasi-linear utility, we analyze the relationship between regional amenities and the negative slope of the wage curve (see, e.g., Blanchflower and Oswald, 1994), that is, regions with higher unemployment also show lower wages. We show that the sign of the slope is independent of the properties of local amenities. Third, including an endogenous amenity, we argue that not only rents, wages, and unemployment, but also endogenous amenities compensate for differences in exogenous amenities. Fourth, we calculate quality of life in West German counties and compare the unemployment-adjusted quality-of-life measure that is proposed in this paper with the standard quality-of-life measure. In contrast with the measures that were employed by Buettner and Ebertz (2009), our quality-of-life measures for West German counties are not entirely based on land rents.

This paper is organized as follows. Section 2 develops the theoretical model, and Section 3 calculates the quality of life in West German counties. Section 4 concludes the paper.

## 2 Theoretical model

A dynamic model in discrete time, in which one small region out of many regions is considered, is established.<sup>2</sup> Each region is characterized by its land endowment,  $L$ , and many possible non-excludable and non-rival amenities that may affect both output and individual well-being either positively or negatively. However, without loss of generality only a single amenity,  $A$ , with positive effects on consumers and producers, is explicitly modeled. It is considered as a time invariant flow variable.

Homogeneous land is used for either consumptive or productive purposes. Each individual inelastically demands one unit of land, and firms optimally adjust their land demand to land rents,  $R$ . The land market is perfectly competitive, and land rents are adjusted to equalize demand and exogenously given supplies.

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<sup>2</sup>When possible, the time index  $t$  is omitted.

Individuals rationally choose regions under conditions of perfect foresight and perfect mobility to maximize lifetime utility. In any given period, each individual supplies one unit of labor and demands one unit of land, which is used as a proxy for housing. Instantaneous utility is additively separable, and the indirect utility function is as follows:

$$v(y, A) = \psi(y) + \phi(A), \quad \text{with } \psi'' \leq 0 < \psi' \text{ and } \phi'' < 0 < \phi', \quad (1)$$

where  $y$  denotes income minus housing costs. In the comparative statics, we restrict ourselves to quasi-linear utility:  $\psi(y) = y$ . The production technology exhibits constant returns to scale regarding labor and land, and the per-capita-production function is denoted as  $f(l, A)$ , with  $f_l(l, A) > 0 > f_{ll}(l, A)$ ,<sup>3</sup> where  $l$  is land per worker. Both the utility function and the production function are monotonic functions of  $A$ . Firms are units of production with per-capita profits  $\pi = f(l, A) - w - Rl$  if filled by a worker. The output price is normalized to 1, and  $w$  denotes the wage rate. Profit maximization implies  $f_l(l, A) = R$ . If unfilled, firms encounter only the flow opportunity costs of a vacant job,  $c$ .

Frictions and imperfect information in the labor market are modeled by employing a standard search-matching model (see Pissarides, 2000). Normalizing search intensity at 1, the region's concave and linear-homogeneous matching function is defined as  $M(U, V)$ , where  $U$  is the number of unemployed people and  $V$  is the number of vacancies. Defining labor market tightness as  $\theta = V/U$ , we can express the worker arrival rate, i.e., the probability that a firm posting a vacancy finds a worker, as  $q(\theta) := M(1/\theta, 1)$ . According to the properties of the matching process,  $q'(\theta) < 0$  and  $0 > \eta(\theta) > -1$ , where  $\eta(\theta) := q'(\theta)\theta/q(\theta)$  is the matching elasticity. The job-arrival rate, i.e., the probability that an unemployed individual finds a job, is  $\theta q(\theta)$ . To simplify the formal analysis, we exclude on-the-job searching and cross-border searching from the analysis. This assumption implies that immigrants are always initially unemployed. Finally, workers encounter the risk of being fired with the time-invariant (exogenous) probability  $\lambda$ .

As absentee landlords and entrepreneurs are assumed, neither profits nor land rents are considered as sources of financing worker consumption. Furthermore, we assume that landlords could be taxed in a lump sum manner to balance the government budget, which allows to fix unemployment benefits. Alternatively, the federal government could establish

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<sup>3</sup>Partial derivatives are indicated by subscripts.

tax rates and unemployment benefits and balances its budget at the national rather than the regional level.

## 2.1 Present discounted values of utility and profit

Denoting the present discounted value of utility flows of an employed worker and an unemployed individual in the region at time  $t$  by  $J_N(t)$  and  $J_U(t)$ , the Bellman equations for employed and unemployed individuals are as follows:

$$(1+r)J_N(t) = v(w(t) - \tau(w(t)) - R(t), A) + (1-\lambda) \max[J_N(t+1), J_U(t+1), \bar{J}_U(t+1)] \\ + \lambda \max[J_U(t+1), \bar{J}_U(t+1)], \quad (2)$$

$$(1+r)J_U(t) = v(b(t) - R(t), A) + \theta(t+1)q(\theta(t+1)) \max[J_N(t+1), J_U(t+1), \bar{J}_U(t+1)] \\ + (1 - \theta(t+1)q(\theta(t+1))) \max[J_U(t+1), \bar{J}_U(t+1)], \quad (3)$$

where  $r$  is the common constant interest rate. An employed worker achieves instantaneous utility  $v(w(t) - \tau(w(t)) - R(t), A)$ , where  $\tau$  denotes the wage tax burden with  $\tau(0) = 0$ ,  $0 \leq \tau < w$ , and  $0 \leq \tau' < 1$ .<sup>4</sup> With probability  $1 - \lambda$ , this worker not lose her job and has the opportunity to choose between continued work, unemployment in the same region, or migration into unemployment in another region. The maximum present value of utility that is encountered by an unemployed individual in any other region is denoted by  $\bar{J}_U$ . When this individual loses her job, she may choose between only the last two options. An unemployed individual receives unemployment benefits,  $b$ , with  $0 < b < \bar{b} < f - f_l l - \tau(f - f_l l)$ , and thus achieves utility  $v(b(t) - R(t), A)$ . In the next period, she receives the maximum present value of utility of unemployment inside and outside of the region. With probability  $\theta(t+1)q(\theta(t+1))$  she finds a job and is able to opt for the present value of utility that is gained from employment. When production occurs in period  $t+1$ , the present value of employment cannot fall short of the present value of unemployment: that is,  $J_N(t+1) \geq \max[J_U(t+1), \bar{J}_U(t+1)]$ . Similarly, migration is not a dominant strategy of the unemployed if  $J_U(t+1) \geq \bar{J}_U(t+1)$ . In equilibrium, the absence of mobility costs implies  $J_U(t+1) = \bar{J}_U(t+1)$ .

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<sup>4</sup>All flow variables are measured at the end of the period.

With the same procedure the Bellman equations of active and non-active firms can be written as follows

$$(1+r)J_F(t) = f(l(t), A) - w(t) - R(t)l(t) + (1-\lambda) \max[J_F(t+1), J_V(t+1)] + \lambda J_V(t+1), \quad (4)$$

$$(1+r)J_V(t) = -c + q(\theta(t+1)) \max[J_F(t+1), J_V(t+1)] + (1-q(\theta(t+1)))J_V(t+1), \quad (5)$$

where  $J_F(t)$  and  $J_V(t)$  are the present discounted values of the profits of active and non-active firms, respectively. The present discounted value of the profits of an active firm is determined by sum of the immediate cash flow  $f(l(t), A) - w(t) - R(t)l(t)$  and the lagged present values of the profits of active and non-active firms weighted by the probabilities of occurrence  $\lambda$  and  $1 - \lambda$ . The present value of the profits of a non-active firm is the sum of the immediate vacancy costs and the prospective values of being active or non-active weighted by the respective probabilities  $q(\theta(t+1))$  and  $1 - q(\theta(t+1))$ . The region will host active firms only if  $J_F(t+1) \geq J_V(t+1)$ . Free entry and exit drives the present values of the profits of inactive firms down to zero: that is,  $J_V(t+1) = 0$ .

In each period, any active firm shares the total surplus with its workers through generalized Nash bargaining taking as given the wages in other firms as well as  $J_U(t)$  and  $J_V(t)$ :

$$w(t) = \arg \max \{ [J_N(t) - J_U(t)]^\gamma [J_F(t) - J_V(t)]^{1-\gamma} \}, \quad (6)$$

where  $\gamma$  is the exogenously given bargaining power of workers, with  $0 < \gamma < 1$ .

## 2.2 Steady-state equilibrium

The following analysis neglects transitional dynamics and focuses only on the steady states in which production actually occurs.

**Definition 1** *A steady-state equilibrium with production is a triple  $(w, R, \theta)$ , i.e., wage, land rent, and labor market tightness, such that workers and firms maximize the present values of utility and profits, the land market clears, and the number of employed and unemployed individuals, and the amount of land used by each firm are time-invariant.*



Applying this definition, we find the following steady-state equilibrium conditions:

$$rJ_U - [v(b - R, A) + \theta q(\theta)(J_N - J_U)] = 0, \quad (7)$$

$$rJ_N - [v(w - \tau(w) - R, A) + \lambda(J_U - J_N)] = 0, \quad (8)$$

$$J_U = \bar{J}_U, \quad (9)$$

$$rJ_V - [-c + q(\theta)(J_F - J_V)] = 0, \quad (10)$$

$$rJ_F - [f(l, A) - w - Rl + \lambda(J_V - J_F)] = 0, \quad (11)$$

$$J_V = 0, \quad (12)$$

$$f_l(l, A) - R = 0, \quad (13)$$

$$\gamma J_F - (1 - \gamma)(J_N - J_U) = 0, \quad (14)$$

$$\lambda N - \theta q(\theta)U = 0, \quad (15)$$

$$lN + N + U - L = 0. \quad (16)$$

Setting the number of laid-off employees equal to the number of hired unemployed individuals, the labor market flow equilibrium condition (15) ensures a stable employed population  $N$  in the region. Equation (16) is the land market equilibrium condition. The outcome of generalized Nash wage bargaining is characterized by Equation (14), whereas the land demand of firms is determined by Equation (13). Equations (7) and (8) are the Bellman equations for unemployed and employed workers, and Equations (10) and (11) are the Bellman equations for inactive and active firms. Furthermore, perfect mobility implies Equation (9), and free entry and exit lead to Equation (12).

The steady-state equilibrium conditions, which are Equations (7) through (16), determine the equilibrium values of the endogenous variables  $J_U, J_N, J_V, J_F, \theta, N, U, l, w$ , and  $R$ . When the wage is less than the marginal product of labor, active workers and firms are better off than their inactive counterparts:  $w = f - Rl - (r + \lambda)c/q < f - f_l l =$  marginal product of labor,  $J_F = c/q > J_V = 0$ , and  $J_N = J_U + (w - \tau(w) - b)/(\lambda N/U + r + \lambda) > J_U$ .

From the steady-state condition (15), the following equation is obtained:

$$\frac{du}{d\theta} = -\frac{(1 + \eta)u^2 q}{\lambda}, \quad \text{implying} \quad \text{sign} \left( \frac{du}{dA} \right) = -\text{sign} \left( \frac{d\theta}{dA} \right), \quad (17)$$

where  $u = U/(U + N)$  is the unemployment ratio. Labor market tightness and unemployment move in opposite directions as the amenity level changes. To stabilize employment,

an increase in the unemployment ratio must be neutralized by a reduction in the job-arrival rate and, hence, by a looser labor market.

Because of to the non-linearity of the production function, the matching function, and the wage tax, most equilibrium values cannot be determined analytically. However, the steady state can be described in the following condensed form:

$$\psi[b - f_l(l, A)] + \phi(A) - r\bar{J}_U + \frac{c\gamma\theta}{1 - \gamma} = 0, \quad (18)$$

$$\psi[w - \tau(w) - f_l(l, A)] + \phi(A) - r\bar{J}_U - \frac{c\gamma(r + \lambda)}{q(\theta)(1 - \gamma)} = 0, \quad (19)$$

where

$$J_U = \bar{J}_U, \quad J_N = \bar{J}_U + \frac{c\gamma}{q(\theta)(1 - \gamma)}, \quad U = \frac{\lambda L}{(1 + l)\theta q(\theta) + \lambda}, \quad N = \frac{\theta q(\theta)L}{(1 + l)\theta q(\theta) + \lambda},$$

$$R = f_l(l, A), \quad w = f(l, A) - f_l(l, A)l - \frac{c(r + \lambda)}{q(\theta)}.$$

Equation (18) is derived from the Bellman equation for unemployed individuals, Equation (7). Equation (19) is derived from the Bellman equation for employed workers, Equation (8). These two equations determine land use by firms,  $l$ , and labor market tightness,  $\theta$ .

The following statement on existence immediately follows from Equations (18) and (19).

**Proposition 1** *If the production function satisfies the Inada conditions  $\lim_{l \rightarrow 0} f_l(l, A) = \infty$ ,  $\lim_{l \rightarrow \infty} f_l(l, A) = 0$ ,  $\lim_{l \rightarrow 0} [f(l, A) - f_l(l, A)l] = 0$ , and  $\lim_{l \rightarrow \infty} [f(l, A) - f_l(l, A)l] = \infty$ , for any finite amenity level,  $A$ , then there exists a reference present value level,  $\bar{J}_U$ , a level of vacancy costs,  $c$ , and a level of unemployment benefits,  $b$ , such that levels of land use,  $l$ , and labor market tightness,  $\theta$ , exist to satisfy Equations (18) and (19) but still allow for a positive wage level. Hence, a steady-state equilibrium with production exists.*

## 2.3 Quality of life

Equations (7) and (8) can be solved for the present discounted values of utility flows,  $J_U$  and  $J_N$ :

$$J_U = \frac{(r + \lambda)v(b - R, A) + \theta q(\theta)v(w - \tau(w) - R, A)}{r[r + \lambda + \theta q(\theta)]}, \quad (20)$$

$$J_N = \frac{[r + \theta q(\theta)]v(w - \tau(w) - R, A) + \lambda v(b - R, A)}{r[r + \lambda + \theta q(\theta)]}. \quad (21)$$

The present discounted value of utility flows of a currently (un-)employed worker,  $J_U$ , is a weighted average of the instantaneous utility of unemployed and employed workers; the weights are determined by the separation rate, the job-arrival rate, and the interest rate. Because  $w - \tau(w) > b$ , an employed worker achieves higher utility than an unemployed individual. Totally differentiation of  $J_U$  yields the marginal willingness to pay for the amenity of unemployed individuals.<sup>5</sup> Using the mobility equilibrium condition  $J_U = \bar{J}_U$  and the relationship between labor market tightness and unemployment that is described by Equation (17), we can write the marginal willingness to pay for the amenity of an unemployed individual as follows:

$$\begin{aligned} - \frac{dy}{dA} \Big|_U &= \phi' \frac{\theta q + r + \lambda}{\theta q v_y^N + (r + \lambda)v_y^U} \\ &= - \left\{ \underbrace{-1}_{(drJ_U/dR)/(drJ_U/dy)} \frac{dR}{dA} + (1 - \tau') \underbrace{\left[ \frac{\theta q v_y^N}{\theta q v_y^N + (r + \lambda)v_y^U} \right]}_{(drJ_U/dw)/(drJ_U/dy)} \frac{dw}{dA} \right. \\ &\quad \left. + \underbrace{\left[ \frac{(v^N - v^U)(r + \lambda)}{(\theta q + r + \lambda) [\theta q v_y^N + (r + \lambda)v_y^U]} \right]}_{(drJ_U/d\theta q)/(drJ_U/dy)} \underbrace{\left( -\frac{\lambda}{u^2} \right)}_{d\theta q/du} \frac{du}{dA} \right\}. \end{aligned} \quad (22)$$

The willingness to pay for an amenity differs from the willingness to pay under perfect competition, i.e., from  $dR/dA - (1 - \tau')dw/dA$ , in the standard Roback (1982) framework. On the one hand, the weight of wages is less than  $1 - \tau'$ ; on the other hand, the change

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<sup>5</sup>The willingness to pay is defined as the maximum amount of resources that an individual is willing to forgo *in the current period and in every subsequent period independent of the employment status* to be able to consume an infinitesimal additional unit of the amenity in every period. The willingness to pay may depend on the current employment status of an individual. The definition for firms is analogous.

in unemployment affects the willingness to pay via the job-arrival rate  $\theta q$ . Because of the assumption of fixed housing for both employed and unemployed individuals, the weight of rents is unchanged. The weight of net-wage changes is the ratio of the expected utility of one additional income unit in the state of employment and the expected utility of one additional income unit in both states,  $dy/dw$ . Changes in the unemployment rate are weighted by the impact on the job arrival rate,  $d\theta q/du$ , and the ratio of the expected utility increase induced by an increase in the job arrival rate and the expected utility of one additional income unit in both states,  $dy/d\theta q$ .

The marginal willingness to pay for the amenity of an employed worker,

$$-\left. \frac{dy}{dA} \right|_N = \left[ \frac{\theta q v_y^N + (r + \lambda) v_y^U}{(r + \theta q) v_y^N + \lambda v_y^U} \right] \left( -\left. \frac{dy}{dA} \right|_U \right), \quad (23)$$

is larger – in absolute terms – than the marginal willingness to pay of an unemployed individual if individuals are risk averse, i.e., if  $v_y^N < v_y^U$ . Income is less important for the employed than for the unemployed because the present value of expected income of the former is higher.

The following proposition compares the willingness to pay across models and states of nature.

**Proposition 2** (i) *The change in land rents has the same weight in the formula for the willingness to pay for an amenity with and without search frictions.*

(ii) *The weight of the change in the wage rate is smaller for an imperfect labor market than for a perfect labor market. (iii) Risk averse unemployed individuals are willing to pay less for amenities than employed workers (in absolute terms).*

For more than one amenity, a regional quality-of-life index for mobile (unemployed) individuals can also be determined. Quality of life in region  $j$  is given by the following:

$$QOL_j = - \sum_i A_{ij} \left. \frac{dy}{dA_i} \right|_U. \quad (24)$$

Solving Equations (10) and (11), we can express the present discounted values of profit

flows for a firm as follows:

$$J_V = \frac{q(\theta)[f(l, A) - lR - w] - (r + \lambda)c}{r[q(\theta) + r + \lambda]}, \quad (25)$$

$$J_F = \frac{[q(\theta) + r][f(l, A) - lR - w] - \lambda c}{r[q(\theta) + r + \lambda]}. \quad (26)$$

A firm's value of profit flows is a weighted average of instantaneous profits of an active firm and vacancy costs in which the weights are determined by the separation rate, the job-filling probability, and the interest rate. An active firm has greater value than an inactive firm. Taking the total differential of  $J_V$  and considering  $J_V = 0$  and  $(f_l - R)dl/dA = 0$ , we obtain the marginal willingness to pay for the amenity of an inactive firm:

$$\begin{aligned} -\frac{dy}{dA}\Big|_V &= \frac{qf_A}{r + q + \lambda} \\ &= \frac{q}{r + q + \lambda} \left( l \frac{dR}{dA} + \frac{dw}{dA} \right) + \left[ \frac{(r + \lambda)(f - lR - w + c)\lambda\eta}{(r + q + \lambda)^2 u^2 \theta (1 + \eta)} \right] \frac{du}{dA}. \end{aligned} \quad (27)$$

Similar to consumers, firms deviate from firms acting on perfect labor markets in their willingness to pay for amenities by a term that captures changes in unemployment. The marginal willingness to pay for the amenity of an active firm,

$$-\frac{dy}{dA}\Big|_F = \left( \frac{r + q}{q} \right) \left( -\frac{dy}{dA}\Big|_V \right), \quad (28)$$

is larger – in absolute terms – than the marginal willingness of an inactive firm to pay, because only active firms are directly affected by the amenity.

## 2.4 Quasi-linear utility

Throughout this subsection, it will be assumed that utility is quasi-linear:  $v = y + \phi(A)$ . Taking the total differential of conditions (7) through (16), we can determine the effect of changes in the amenity level. Specifically, the comparative static exercise yields the following:

$$\frac{dR}{dA} = \frac{(1 - \tau')q^2 f_A \gamma + \phi' \{q^2 \gamma - [1 - (1 - \gamma)\tau']q'(r + \lambda)\}}{\Delta}, \quad (29)$$

$$\frac{dw}{dA} = \frac{(f_A - l\phi')\gamma[q^2 - q'(r + \lambda)]}{\Delta}, \quad (30)$$

$$\frac{d\theta}{dA} = \frac{(1 - \tau')(f_A - l\phi')\gamma q(r + \theta q + \lambda)}{[w - \tau - b]\Delta}, \quad (31)$$

where

$$\Delta = [1 + (1 - \tau')l]q^2\gamma - q'[1 - (1 - \gamma)\tau'](r + \lambda) > 0.$$

The following proposition summarizes the main comparative static effects.

**Proposition 3** *Suppose that utility is quasi-linear.*

- (i) *The effects of any amenity on wages and unemployment rates have opposite signs.*
- (ii) *If the amenity is productive and utility-enhancing, then an increase in the amenity level causes an increase in land rents.*
- (iii) *If the amenity is marginally more beneficial to producers than to consumers per unit of land, i.e., if  $f_A/l > \phi'$ , then wage rate and labor market tightness increase, and the unemployment ratio decreases in response to an increase of the amenity level.*

If the amenity does not directly affect consumers, then a productive amenity increases land rents, wages, and labor market tightness. Similarly, if the amenity has no direct effect on production, then a utility-enhancing amenity increases land rents but reduces wages and labor market tightness. Whereas a positive amenity unambiguously increases the value of land, the overall-effect of amenities on labor market indicators depends on the relative strength of the positive effects. Wages increase and unemployment decreases if an increase in the amenity level benefits firms more than workers. Analogous statements are possible for disamenities.

Figures 1 and 2 show how utility and productivity-enhancing amenities simultaneously affect rents, wages, and labor market tightness.<sup>6</sup> In any case, the wage curve in an unemployment-wage diagram would be downward-sloping as empirically confirmed by Blanchflower and Oswald (1994) (see also, among others, Card, 1995; Suedekum, 2005; Nijkamp and Poot, 2005; Blanchflower and Oswald, 2005). The reason is that both wages and labor market tightness negatively affect the value of inactive firms and positively affect the present value of unemployed individuals. Moreover, the steady state condition (15) implies that the unemployment ratio and the indicator of labor market tightness are negatively correlated. Whereas the land rent compensates for the aggregate effect of an

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<sup>6</sup>Without any explicit analytical underpinning, Deller (2009) derived Figure 2.

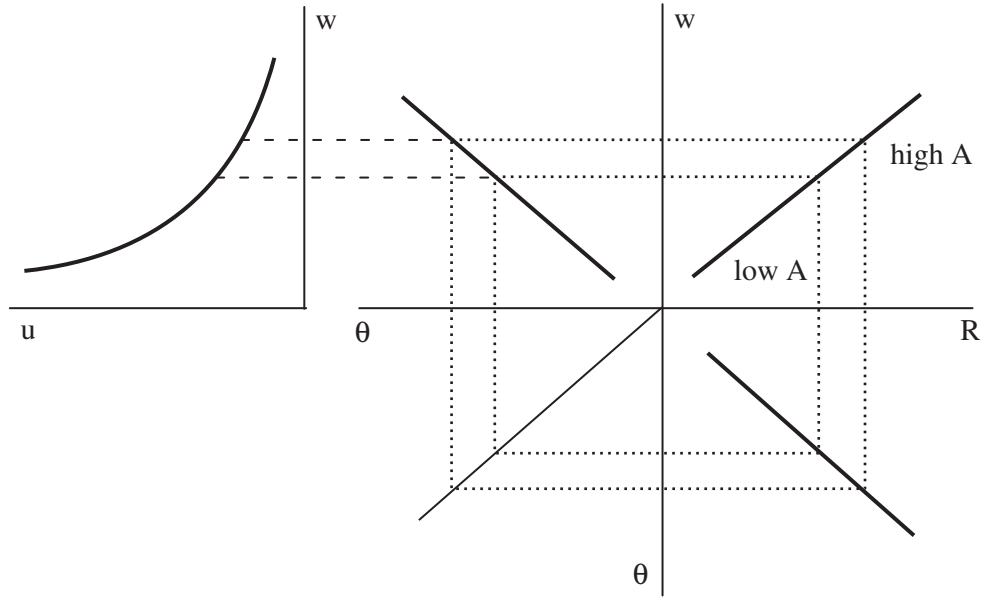


Figure 1: Amenity level, wages, rents, and labor market tightness if  $v = y + \phi(A)$  and  $f_A/l > \phi' > 0$

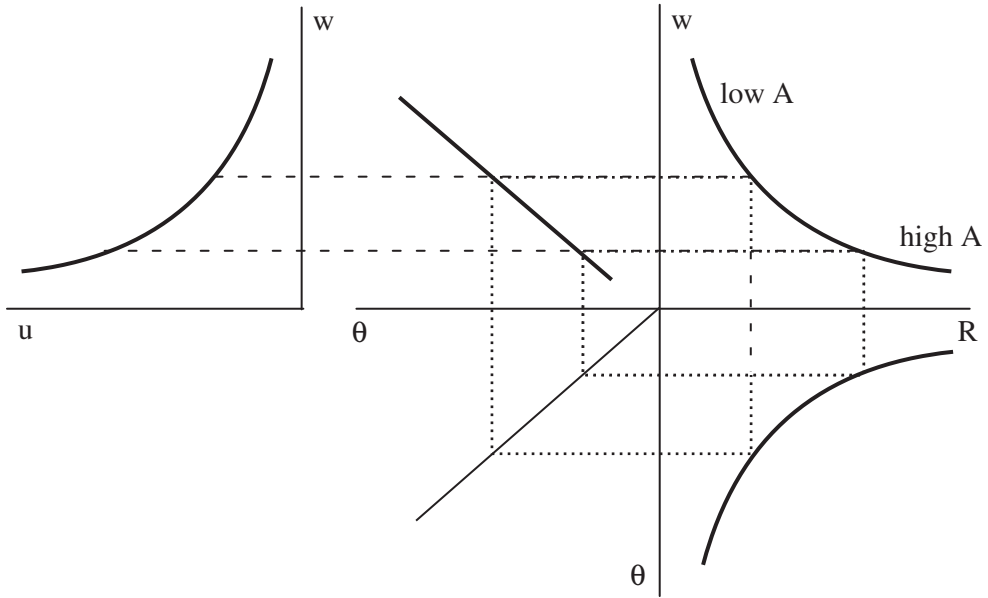


Figure 2: Amenity level, wages, rents, and labor market tightness if  $v = y + \phi(A)$  and  $0 < f_A/l < \phi'$

amenity, changes in wages and unemployment are driven by the difference between the effects of the amenity on firms and workers.<sup>7</sup> Furthermore, because

$$\frac{(1 - \tau') \frac{dw}{dA} - \frac{dR}{dA}}{\frac{du}{dA}} = \frac{(w - \tau - b)\lambda}{(1 + \eta)(ru + \lambda)uq^2} \left[ q'(r + \lambda) + \frac{\phi' \Delta}{(1 - \tau')(f_A/l - \phi')l} \right], \quad (32)$$

even the after-tax real-wage curve is downward-sloping if  $\phi' > f_A/l$ , i.e., if active firms require higher compensation than consumers.

If workers were risk adverse, i.e., if  $\psi'' < 0$ , then the effects of amenities on wages, rents, and labor market tightness could not be signed. Risk aversion may even imply an upward-sloping wage curve.

Using the reduced form of the steady state given by Equations (18) and (19), we can analyze the effect of a variation in the amenity supply on land use by firms and labor market tightness. Because

$$\left. \frac{dl}{d\theta} \right|_{J_N} = \frac{\frac{(r+\lambda)c[1-(1-\gamma)\tau']}{1-\gamma} \frac{q'}{q^2}}{f_u[1+l(1-\tau')]} > 0 \text{ and } \left. \frac{dl}{d\theta} \right|_{J_U} = \frac{c\gamma}{f_u(1-\gamma)} < 0, \quad (33)$$

Equation (18), which is related to  $J_U$ , has a negative slope, and Equation (19), which refers to  $J_N$ , has a positive slope in the  $\theta - l$ -space (see Figure 3). Hence, for quasi-linear utility the steady-state equilibrium with production is unique.

Differentiation of these equations with respect to  $A$  indicates that the downward-sloping  $J_U$  curve shifts downward if and only if  $f_{lA} - \phi' < 0$ , whereas the upward-sloping  $J_N$  curve shifts downward if and only if  $-(1 - \tau')f_A - \phi' + [1 + l(1 - \tau')]f_{lA} < 0$ . Hence, if land and the amenity are substitutes, i.e., if  $f_{lA} < 0$ , then an increase in the supply of a utility-enhancing and productivity-enhancing amenity reduces land use in production, but has an ambiguous effect on labor market tightness (see Figure 3).<sup>8</sup>

Whereas any change in the amenity level in a small open region with free entry and exit cannot alter the well-being of unemployed workers and inactive firms, employees and active firms – who are better off than their inactive counterparts – are practically immobile and

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<sup>7</sup>If land prices were the same in all regions, higher wages must compensate for higher unemployment if workers search only locally (see, e.g., Molho, 2001).

<sup>8</sup>Further analysis of the total differential shows that the sign of  $f_A - l\phi'$  is, indeed, crucial for the effect on labor market tightness, as previously stated.



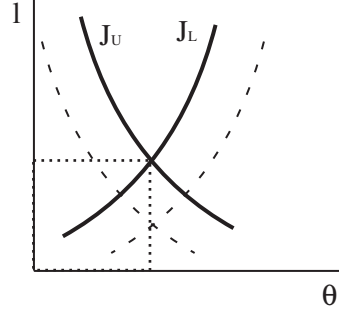


Figure 3: Amenity level, land use by firms, and labor market tightness if  $v = y + \phi(A)$ ,  $f_A > 0$ ,  $\phi_A > 0$ , and  $f_{LA} < 0$

are thus affected by changes in amenity levels. Inserting for  $dR/dA$ ,  $dw/dA$ , and  $d\theta/dA$ , we can calculate total differentials as follows:

$$\frac{dJ_N}{dA} = (1 - \tau')\gamma \frac{(\phi' - f_A/l)lq'}{\Delta}, \quad (34)$$

$$\frac{dJ_F}{dA} = (1 - \tau')(1 - \gamma) \frac{(\phi' - f_A/l)lq'}{\Delta}. \quad (35)$$

Employed workers benefit more than marginal workers from an increase in the amenity level if and only if  $f_A/l > \phi'$ . The same statement applies to active firms relative to inactive firms. The intuition is simply that the benefits of consumption amenities are independent of employment and activity status, but productive benefits are particularly valuable for firms that actually produce.

For quasi-linear utility, the marginal willingness of both unemployed and employed individuals to pay for an amenity depends only on observable variables:

$$\begin{aligned} - \frac{dy}{dA} \Big|_U = - \frac{dy}{dA} \Big|_N = \phi' &= \frac{dR}{dA} - (1 - \tau') \left( \frac{\lambda N/U}{\lambda N/U + r + \lambda} \right) \frac{dw}{dA} \\ &+ \left\{ \frac{(w - \tau - b)(r + \lambda)\lambda}{(\lambda N/U + r + \lambda)^2 u^2} \right\} \frac{du}{dA}. \end{aligned} \quad (36)$$

This formula, which is derived from Equations (22) and (23), can easily be used in the empirical estimations of the quality of life.<sup>9</sup>

<sup>9</sup>Gyourko and Tracy (1991) argued that tax prices should be included as far as local public services are concerned. If the amenity were a publicly provided private good financed by a uniform head tax that is levied on all citizens in the region under consideration, then Equation (36) would measure the willingness to pay for the publicly provided good in excess of marginal costs:  $\phi' -$  marginal costs.

For quasi-linear utility, it is also possible to conduct a more rigorous comparison of the standard approach that relies only on land rents and wages with the approach that is proposed in this paper. Using comparative statics, namely,

$$\frac{du}{dw} = -\frac{(1 - \tau')(1 + \eta)(\lambda + ru)u}{(w - \tau - b)\left(1 - \eta \frac{r+\lambda}{\lambda} \frac{U}{N}\right)\lambda}, \quad (37)$$

to express  $du/dA$  in terms of  $dw/dA$ , the marginal willingness of workers and inactive firms to pay is expressed as follows:

$$-\frac{dy}{dA}\Big|_U = -\frac{dy}{dA}\Big|_N = \frac{dR}{dA} - \left(\frac{1 - \tau'}{1 - \eta \frac{r+\lambda}{\lambda} \frac{U}{N}}\right) \frac{dw}{dA}, \quad (38)$$

$$-\frac{dy}{dA}\Big|_V = \frac{q}{r + q + \lambda} \left[ l \frac{dR}{dA} + \left(\frac{1 - \eta \frac{1-(1-\gamma)\tau'}{\gamma} \frac{(r+\lambda)}{\lambda} \frac{U}{N}}{1 - \eta \frac{r+\lambda}{\lambda} \frac{U}{N}}\right) \frac{dw}{dA} \right]. \quad (39)$$

Because the coefficient of a change in wages for a worker in Equation (38) lies in the interval  $-(1 - \tau'), 0)$ , the proposition below immediately follows.

**Proposition 4** *Suppose that utility is quasi-linear. The standard procedure to calculate the marginal willingness to pay for an amenity, provided that it entirely disregards unemployment overestimates (underestimates) the willingness of mobile workers to pay if the amenity reduces (increases) the wage, i.e. if  $f_A/l < \phi'$  ( $f_A/l > \phi'$ ).*

Hence, if, on average, local amenities are more beneficial to consumers than to producers the unemployment adjusted measure would indicate lower quality of life than the non-adjusted measure.

Furthermore, the aggregate marginal willingness to pay for an increase in the amenity level can be written as follows:

$$\begin{aligned} (N + U)\phi' + N \frac{(r + q)f_A}{r + q + \lambda} + V \frac{qf_A}{r + q + \lambda} &= (N + U)\phi' + Nf_A \\ &= L \frac{dR}{dA} + \frac{Nq(\phi' - f_A/l)l\{(1 - \tau'/u)\gamma\lambda + [1 - (1 - \gamma)\tau']\eta(r + \lambda)\}}{\theta\Delta}. \end{aligned} \quad (40)$$

This expression differs from the respective value under perfect labor markets, i.e., from  $L dR/dA$  (see Roback, 1982). If the bargaining power of workers is not excessively strong and the amenity primarily enhances utility, i.e., if  $\phi' > f_A/l$ , the change in aggregate

land rents would overestimate the total willingness to pay. If jobs were chosen efficiently, i.e., if  $\gamma = -\eta$  (see Pissarides, 2000), and wage taxation were lump sum conditional on employment, i.e.,  $\tau' = 0$ , then this condition could be written as follows:

$$(N + U)\phi' + Nf_A = L \frac{dR}{dA} + Nr \left( \frac{dJ_N}{dA} + \frac{dJ_F}{dA} \right).$$

In summary, workers and firms are willing to forego land rents and profits.

## 2.5 Endogenous amenities

As yet, the paper investigated only exogenous amenities. Following Brueckner, Thisse, and Zenou (1999) and Tivadar (2010), amenities could be considered as endogenous that is, the level depends on population size, income, or some other endogenous variable. The analysis could easily be extended to include endogenous amenities. To exemplify the effects of these amenities, an endogenous amenity  $G(N)$ , with  $G'' < 0 < G'$ , is introduced into the model which depends positively on the number of active workers and increases output and utility. Without fully solving the model, the change in the quality-of-life formula could be demonstrated if it is assumed that utility is quasi-linear and depends also positively on  $G$  according to a function  $\varphi(G)$ , with  $\varphi'' < 0 < \varphi'$ . Hence:  $v = y + \phi(A) + \varphi(G)$ . The marginal willingness to pay for the exogenous amenity, Equation (36), can now be written as follows:

$$\begin{aligned} -\frac{dy}{dA} = & -\varphi'(G) \frac{dG}{dA} + \frac{dR}{dA} - (1 - \tau') \left( \frac{\lambda N/U}{\lambda N/U + r + \lambda} \right) \frac{dw}{dA} \\ & + \left\{ \frac{(w - \tau - b)(r + \lambda)\lambda}{(\lambda N/U + r + \lambda)^2 u^2} \right\} \frac{du}{dA}. \end{aligned} \quad (41)$$

Rents, wages, unemployment, and endogenous amenities compensate for differences in exogenous amenities. If the exogenous and the endogenous amenity were positively correlated rather than uncorrelated, compensating rent differentials would be larger.

## 3 Empirical application

To complement the theoretical comparison of the unemployment-adjusted quality-of-life measure that is proposed in this paper with the standard quality-of-life measure, we will

calculate the quality-of-life indices for regions in West Germany. Aggregate data on 326 West German counties for 1998 through 2007 will be used for the empirical exercise.<sup>10</sup> The average price for land ready for construction per m<sup>2</sup> and harmonized consumer prices are taken from the online data pool of the Federal Statistical Office, all other data are provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development via INKAR 2010. The main endogenous variables are the gross wage incl. employee's social security contribution in Euro (wage), the share of unemployed in the workforce (unemprate), and the imputed rent (imputedrent). The latter is the price for building land times nominal interest rate (0.05) times average lot size (752.68 m<sup>2</sup>) divided by the average number of housing units per structure (1.479); average lot size and housing units per structure are taken from Buettner and Ebertz (2009). To be able to determine average numbers, consumer prices are used to adjust wages and land prices for inflation. The tax rate incl. employee's social security contribution is set to 0.5 which is consistent with OECD data (see, e.g., OECD, 2009).<sup>11</sup> To control for the composition of the workforce, the share of workers with only primary education among regularly employed workers (sharelowskilled), the share of workers with tertiary education (sharehighskilled), the share of manufacturing workers (shareoccmanufacturing), and the share of service workers (shareoccservices) are included. As control for residential density in the newly built areas, the share of one- and two-family homes among the newly built houses (sharenewfamhome) is considered. Data aggregated at the county level are used because comprehensive individual land market data with full information on house characteristics are not available for Germany.

In the empirical analysis, we assume quasi-linear utility and calculate the quality of life of workers in West German counties based on Equations (36) and (24). However, instead of adding up marginal effects of many amenities, we calculate county fixed effects. This

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<sup>10</sup>East Germany has been excluded from the analysis because mobility between the two parts of Germany is clearly imperfect. Unfortunately, this exclusion substantially reduces the variance in wages and unemployment rates. Furthermore, this choice may also reduce the calculated quality of life in districts that are close to the former border between the Federal Republic of Germany and the German Democratic Republic.

<sup>11</sup>In Germany, social security contributions, the income tax rate, and the so called solidarity surcharge are determined at the federal level. Neither the Länder nor the municipalities have the right to levy income taxes.

approach has the advantage that the results do neither depend on the selection of amenities nor on data quality regarding amenities (see, e.g., Albouy, 2009). Furthermore, it is not necessary to distinguish between exogenous and endogenous amenities and to tackle the endogeneity problem in the empirical specification. A shortcoming of this study is that aggregate panel data rather than micro-data are used; hence, each county fixed effect is identified with only 10 observations. Furthermore, the use of panel data relies on the assumption that differences in amenity levels across counties are constant over time.

The empirical model for the endogenous variable  $Y$  being either wage, imputed rent, or unemployment rate is

$$Y_{it} = \beta_{y0} + \sum_k \beta_{ky} X_{kit} + a_{yi} + b_{yt} + u_{yit}, \quad (42)$$

where  $i$  indicates the county and  $t$  the period, and  $u_{yit}$  is the error term. Year dummies  $b_{yt}$  and control variables  $X_{kit}$  (sharelowskilled, sharehighskilled, shareoccmanufacturing, shareoccservices, sharenewfamhome) are included. The variable of interest is the county fixed effect  $a_{yi}$ .

Variable	Mean	Std. Dev.	Min.	Max.	N
imputedrent	313.409	258.777	31.477	2959.159	2878
wage	2739.772	291.392	2076.849	4446.409	3260
unemprate	0.091	0.031	0.024	0.256	3260

Table 1: Summary statistics

Variables	imputedrent	wage
wage	0.527 (0.000)	
unemprate	-0.121 (0.000)	0.034 (0.056)

Table 2: Cross correlations

Tables 1 and 2 show the summary statistics and cross-correlations of the main variables in the model. High-cost regions are also high-wage regions but the relationship with unemployment is inconclusive. Most interestingly, a variance decomposition of county

dependent variable	imputedrent	wage	unemprate
sharelowskilled	-4.045 (3.307)	-13.24*** (2.217)	0.000357 (0.000267)
sharehighskilled	-22.35** (9.003)	6.640 (9.217)	0.000842 (0.000881)
shareoccmufacturing	-8.468* (4.760)	-10.75* (5.467)	0.000434 (0.000629)
shareoccservices	-6.656* (3.748)	-23.37*** (5.745)	0.00162*** (0.000544)
sharenewfamhome	1.275 (0.887)	-0.120 (0.329)	8.34e-05 (5.22e-05)
Constant	1,129*** (401.0)	4,826*** (499.0)	-0.0290 (0.0485)
Year dummies	yes	yes	yes
County fixed effects	yes	yes	yes
Observations	2,789	3,167	3,167
R <sup>2</sup> within	0.0689	0.607	0.647
R <sup>2</sup> between	0.590	0.191	0.0869
R <sup>2</sup> overall	0.421	0.203	0.163
$\rho$	0.940	0.968	0.938

Robust standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, and \* p<0.1

Table 3: Regression of imputed rents, wages, and unemployment rate

unemployment rates reveals that the contribution of the between variance is rather high,  $\rho = 0.85$ , indicating that persistent differences across local labor markets exist. Since the Rosen-Roback framework implicitly assumes that the variation of outcomes across local labor markets is to a large extent idiosyncratic, the existence of persistent differences provides strong support for the application of the approach developed in this paper.

Variable	Mean	Std. Dev.	Min.	Max.	N
countyimputedrent	-415.734	311.764	-760.050	1615.807	326
countywage	-395.484	255.631	-883.001	652.472	326
countyunemprate	0.037	0.028	-0.026	0.136	326

Table 4: County fixed effects

Table 3 shows the results for the fixed effect regressions, Equation (42), and Table 4 provides summary statistics on county fixed effects. Because the county Bonn ist chosen as reference category, all county fixed effects must be understood as differentials relative

to Bonn. To calculate the quality-of-life index relative to Bonn the county fixed effects are summed up using the weights given by Equation (36).<sup>12</sup>

As shown in Figure 4, the quality of life is especially high in the metropolitan areas of Munich, Stuttgart, Rhein-Main, Rhein-Ruhr, Hamburg, and Nuremberg, whereas most counties in the central regions, such as northeastern Hesse, northeastern Bavaria, part of Rhineland-Palatinate, and large parts of Lower Saxony, appear to be less amenable for workers.<sup>13</sup> On average, cities that enjoy county status are more highly ranked than counties. Interestingly, there is a statically significant positive correlation between the quality-of-life index and netimmigration ( $\rho = 0.318$ ).

indices	qol	qolred	qolrr	countyimputedrent
qolred	0.997 (0.000)			
qolrr	0.995 (0.000)	0.999 (0.000)		
countyimputedrent	0.949 (0.000)	0.940 (0.000)	0.928 (0.000)	
realcosts	0.931 (0.000)	0.940 (0.000)	0.947 (0.000)	0.813 (0.000)

Table 5: Cross correlations

To evaluate the quality-of-life index based upon explicitly modeling unemployment, we compare the quality-of-life index (qol) with various other rankings (see Table 5): the quality-of life index based on the reduced form determined by Equation (38) in which  $du/dw$  is obtained from the model rather than from the empirical correlation (qolred), the standard Rosen-Roback quality-of-life index where the wage effect has weight  $-(1 - \tau')$  (qolrr), and the real costs of living defined as average local rent minus average local net wage (realcosts). All rankings are highly correlated, but the correlation between the real costs of

<sup>12</sup>Following Hobijn and Sahin (2009), we set  $\lambda = 0.0106$ . Their estimation is between the findings of Bauer and Bender (2004) (0.0155) and Bellmann, Gerner, and Upward (2011) (0.0088). Following Buettner and Ebertz (2009), we set  $r = 0.05/12$ .

<sup>13</sup>It should be emphasized that absolute numbers and ranks are sensitive to changes in the assumptions regarding lot size and interest rate. However, in particular, the top ranking of the Munich area is independent of varying parameter settings.

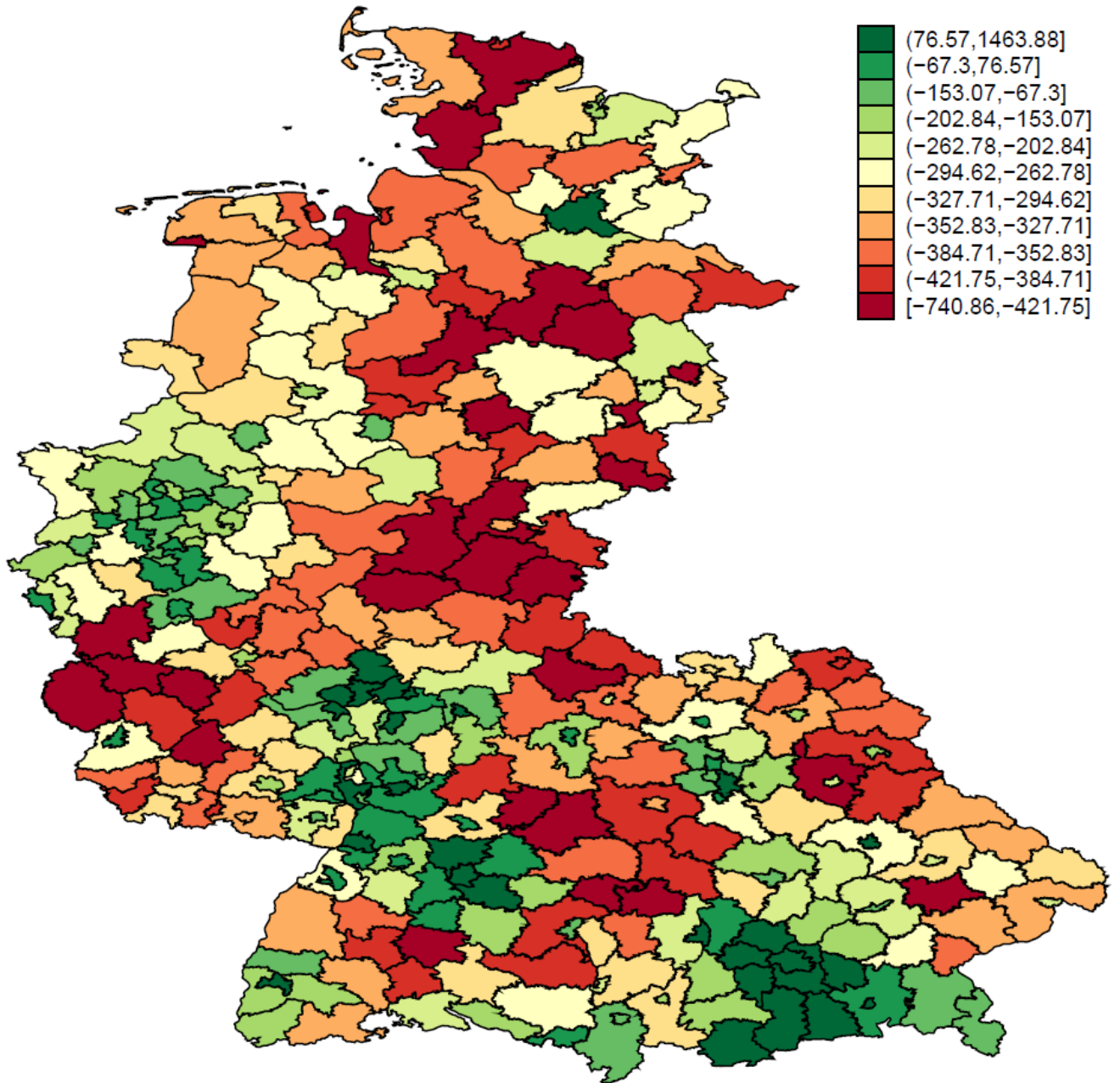


Figure 4: Quality of life in West German counties in 1997-2008



living and the quality-of-life indices is lower than the correlation of any two quality-of-life indices. The inclusion of year dummies and further control variables in the calculation affects the quality-of-life indices substantially. Although, in contrast to the prediction of the model, the indices  $qol$  and  $qolred$  are slightly different, they still look similar. The small difference could be attributed to the low spatial variance of wages in West Germany. According to Equation (37), the model predicts for average wages and unemployment rates that  $(dw/w)/(du/u) \approx -1.13$  if  $\eta = -0.6$  (see Rogerson and Shimer, 2011). In West Germany, wages exhibit significantly less variance across counties compared with the predictions of the model. Either collective bargaining and other omitted variables in the wage regression or risk aversion could explain this discrepancy. The low variation of wages across counties also explains the similarity between the standard index  $qolrr$  and the two indices  $qol$  and  $qolred$ . As Table 4 demonstrates, the variation in wage effects is lower than the variation in rent effects and net wage effects, i.e., wage effects multiplied with the tax factor,  $1 - \tau'$ , are much smaller than rent effects. To a large extent, all quality-of-life indices are determined by county fixed effects. The correlation with the county fixed effects varies between 0.928 and 0.949 (see Table 5).

## 4 Concluding remarks

Combining a spatial equilibrium model with a matching unemployment model, this paper analyzed regional quality of life when wages, rents, and unemployment risk compensate for local amenities and disamenities. In particular, for quasi-linear utility, the paper shows that the effects of any amenity on wages and unemployment rates are of opposite signs; wage rates and labor market tightness increase and the unemployment ratio decreases in response to an increase in the level of an amenity that is marginally more beneficial to producers than to consumers per unit of land. Based on the model, the quality of life of workers in West German counties was calculated.

However, the theoretical model has omitted several important issues. Neither on-the-job searches nor migration costs were considered. Agglomeration externalities and inter-regional spillovers were also disregarded. Furthermore, although the model assumed that immigrants are initially unemployed, migration of unemployed individuals after successful

job search is much more common. Regarding the empirical application, it would clearly be worthwhile to use micro data. For Germany, rich micro data sets exist for labor markets, but not for housing markets. Finally, the theoretical model assumed congruent labor and housing markets, but counties are actually poor proxies for these markets because housing markets are often smaller and labor markets are larger. However, all of these theoretical and empirical issues can be investigated in future research.

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