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Abstract

Employing a standard matching unemployment model extended by within-labor-market-regions commuting, this paper analyzes the tradeoff between commuting costs and unemployment. Depending on whether commuters are able to bargain for fringe benefits, search may or may not be biased towards distant workplaces and less productive centers. As a consequence, unemployment benefits should be tied to search in high productivity regions. Using German county data, the paper tests some positive predictions that emerge from of the model. In particular, it confirms that increasing labor market tightness reduces the willingness to out-commute.

JEL Classification: R12, R13, R14, H22.

Keywords: Unemployment, matching, commuting, search, labor market policy.

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1 Introduction

While flexible labor markets may be more prone to adverse economic shocks than rigid markets, flexibility helps overcome high unemployment. First and foremost, flexibility stands for the absence of rigid labor market regulations and, thus, low costs for hiring and firing. Second, flexibility also means flexible workers which includes life-long learning and job mobility. Thus, the unemployed should be willing to search for jobs outside their home region. For the U.S., Blanchard and Katz (1992) have shown that residential mobility effectively equilibrates regional disparities in regional unemployment and wage levels. After the recent financial crisis, the lower mobility of labor has been responsible for the slow recovery in the U.S. While smoothing asymmetric shocks on a large spatial scale requires high residence mobility, on a small scale, commuting suffices to smooth the shocks. The readiness to commute raises the probability of successful matches and reduces the average duration of unemployment. Even in continental Europe where unemployment benefits have been rather generous, the unemployed are now asked to accept job offers that imply either a long commute or a substantial relocation. However, in imperfect labor markets with substantial matching and dismissal costs, workers may be locked into jobs with inefficient long commutes. An increase in the acceptance rate of jobs with long commutes, on the one hand, reduces unemployment but, on the other hand, increases commuting costs. This tradeoff between commuting costs and the costs of unemployment is the subject of this paper which aims to model the tradeoff by employing an empirically valid model. Using data on German counties, the paper analyzes the impact of unemployment on the propensity to commute.

For Germany, migration is an effective albeit a slow means of labor-market adjustment (Möller, 1995), as migration is considered only after local job searches were unsuccessful (Arntz, 2005). However, the low-skilled job seeker rarely responds to local labor-market conditions (Arntz, 2005). The duration of unemployment benefits affects the migration rates of the high-skilled unemployed as they face high replacement rates (Arntz, Loz, and Wilke, 2008). As opposed to migration, the effect of unemployment on commuting has been widely neglected in the theoretical and empirical literature, though it is well known that long-distance commuting from the east, beleaguered by unemployment, to the west is prevalent. In the hopes of better local labor-market conditions in the future, those living in the east choose to commute rather than migrate (Pischke, Staat, and Vögele, 1994).

The paper has its roots in search-matching models of unemployment (see, e.g., Mortensen and Pissarides, 1994; Diamond, 1984; Pissarides, 2000; Petrongolo and Pissarides, 2001), and, more specifically, in the literature on urban-search-matching. Van Ommeren, Rietveld, and Nijkamp (1998, 2000) introduced searching in the housing market, commuting, and migration into a search-matching model of unemployment. Smith and Zenou (2003) Wasmer and Zenou (2002, 2006), and Zenou (2009a,b) fully elaborate on the land market in an urban search-matching framework where space is continuous. Empirical work on mobility, commuting, and search includes Van Ommeren, Rietveld, and Nijkamp (1999). Patacchini and Zenou (2005) confirmed the negative relationship between search intensity and distance to jobs. The model developed in this paper differs mainly in two respects from the afore mentioned urban-search-matching literature. First, to simplify, the model presented here excludes migration and, therefore, the land market from the analysis. Given their current locations, workers decide either to search for jobs that do or do not require a commute. For countries with high residential mobility, this model-strategy is probably inappropriate for analyzing over the long term, but for countries such as Germany, where residential mobility later in life is quite low, this strategy is an appropriate shortcut. Second, the model considers only a finite number of regions as the spatial units this study considers are not blocks and neighborhoods but counties and cities in a metropolitan area with more than one employment center. Moreover, our model strategy substantially reduces modeling complexity compared to a multi-region model with continuous space and distance-dependent search intensity. The model used is closest to that of Coulson, Laing, and Wang (2001), who constructed a model that was consistent with spatial mismatch across cities. Our model differs from theirs, however, in various respects. For example, we consider global matching rather than local matching. Also the traveling costs for job searching and commuting differ in our model, and we focus on unemployment benefits. More importantly, in their model, each unemployed worker searches effectively in just one region, while our model stresses simultaneous searches in more than one region. The paper is also related to Zenou (2007), who considers a circle along which both workers and firms are located. In his model, each worker searches the entire market and accepts all job offers below some cut-off distance level (see also, Zenou, 2009b, pp. 132-142). Although this model captures intensive and extensive searches, differences in search intensity for jobs in different locations could not be distinguished from search intensity as such. Furthermore, in his model there are no location-specific productivity effects, while we incorporate such effects.

The paper contributes to the literature by developing a simple multi-region model of search-matching unemployment and commuting that allows for analyzing the effects of unemployment benefits. It suggests that there is a tendency for searches to be biased towards distant workplaces and/or less productive regions. As a consequence, unemployment benefits should provide comparatively strong incentives to search locally and to search in high-productivity regions. The paper considers two different wage formation processes. In the first scenario, members of one and the same union, non-commuters and commuters bargain collectively with employers over a uniform region-specific wage. As a result, any single firm is indifferent toward employing a non-commuter or a commuter. In the second scenario, assuming high costs of resolving a successful match, after the match has been determined, the employer bargains with the applicant. Since commuters face additional costs, bargaining results in higher wages for the commuter than for the non-commuter. This positive wage differential is consistent with the fact that many firms provide certain amenities for commuters such as free parking and reduced public transportation fares.

To test whether the model is consistent with empirical regularities, some findings of the model are tested with German county data. The empirical analysis confirms several positive predictions of the model, namely, the higher the local wage, the lower the average wage in neighboring regions, the higher commuting costs, or the higher the ratio of vacancies to unemployment, the less likely workers out-commute. The data show that lower labor market tightness induces more intensive searches for jobs with long commutes.

The paper is organized as follows. Section 2 develops the theoretical model of unemployment and commuting with a particular focus on normative implications. The predictions of the model on commuting behavior are tested in Section 3. Section 4 concludes the paper.

2 Theoretical model

A dynamic symmetric two-region model in continuous time is established.[1] Residences are exogenous, but individuals may work in either region. Commuting costs are denoted by k.

Firms are units of production with per-capita revenues p if filled by a worker and flow opportunity costs of a vacant job denoted by c. A worker earns w if she is employed and achieves a (non-pecuniary) benefit z in case of unemployment. While p, c, and z are exogenously given parameters, w is endogenously determined.

Frictions and imperfect information in the labor market are modeled by employing a now standard search-matching model, as in Pissarides (2000). To simplify the formal analysis, w.l.o.g. on-the-job search is excluded from the analysis. The linear homogeneous overall matching function with positive, but diminishing partial derivatives is defined as $M(\sum_{i=1}^{2}\sum_{j=n,c} s_{ji}U_i, V_1+V_2)$, where U_i is the number of the unemployed in region i and V_i is the number of vacancies. s_{ni} and s_{ci} indicate search intensity in region i for jobs without a commute (n) and jobs with a commute (c), respectively. Defining $m(x) \equiv M(1,x)$, the individual probability of transition from unemployment to employment with commuting status j of a citizen of region i is written as

$$q_{ji} = s_{ji}\, m\left(\frac{V_1+V_2}{\sum_{k=1}^{2}\sum_{l=n,c} s_{lk}U_k}\right). \tag{1}$$

Due to the properties of the matching function, $m' > 0 > m''$ and $0 < \epsilon(x) < 1$, where $\epsilon(x) = m'(x)x/m(x)$, for $x > 0$. Defining the overall labor-market tightness in a symmetric equilibrium, $\theta = (V_1+V_2)/(U_1+U_2)$, the transition probability is written as $q_i(\theta, s_i, s)] = s_i m(\theta/s), \quad i = c, n$, where $s = s_c + s_n$.[2] The worker arrival rate in region i, that is, the probability that a firm posting a vacancy finds a worker, is

$$q_i^f = \frac{s_{ni}U_i + s_{cj}U_j}{V_i}\, m\left(\frac{V_1+V_2}{\sum_{k=1}^{2}\sum_{l=n,c} s_{kl}U_k}\right), \quad j \neq i. \tag{2}$$

In a symmetric equilibrium, this simplifies to $q^f(\theta, s_n, s_c, s) = [q_c(\theta, s_c, s) + q_n(\theta, s_n, s)]/\theta$. Finally, workers face the risk of being fired with time-invariant (exogenous) probability λ.

[1] For notational simplicity, the time index t is omitted.

[2] In the symmetric setting, the region specific subscript is omitted whenever possible.

We will assume that search costs $\sigma(s_n, s_c)$ are additive separable, symmetric, increasing, and strictly convex. Hence, derivatives satisfy $\sigma_i > 0$ and $\sigma_{ii} > 0$, with $i = n, c$.

If not otherwise stated, a symmetric allocation of resources is considered throughout the paper. $n_c = N_c/N$ and $n_n = N_n/N$ are the fractions of commuters and non-commuters of the total population N in either region.

2.1 Efficiency

Assuming the existence of lump-sum transfers, the social planner chooses employment and search intensity to maximize the present value of the sum of net benefits

$$\max_{\theta, s_n, s_c} \Omega \equiv \int_0^\infty e^{-rt} \left\{ p(n_n + n_c) + [z - \sigma(s_n, s_c) - c\theta](1 - n_n - n_c) - kn_c \right\} dt \qquad (3)$$

taking the matching technology and the evolution of employment

$$\begin{aligned} \dot{n}_n &= q_n(\theta, s_n, s)(1 - n_n - n_c) - \lambda n_n && (4) \\ \dot{n}_c &= q_c(\theta, s_c, s)(1 - n_n - n_c) - \lambda n_c && (5) \end{aligned}$$

as given, where r is the discount rate. Denoting the costate variable of employment adjustment by μ_n and μ_c, the optimality conditions are

$$\begin{aligned} -(p - z + \sigma + c\theta) + \mu_n(q_n + \lambda) + \mu_c q_c + \mu_n r &= \dot{\mu}_n && (6) \\ -(p - z + \sigma + c\theta - k) + \mu_n q_n + \mu_c(q_c + \lambda) + \mu_c r &= \dot{\mu}_c && (7) \\ -(1 - n_n - n_c)\left(c - \mu_n \frac{\partial q_n}{\partial \theta} - \mu_c \frac{\partial q_c}{\partial \theta} \right) &= 0 && (8) \\ -(1 - n_n - n_c)\left(\sigma_n - \mu_n \frac{\partial q_n}{\partial s_n} - \mu_n \frac{\partial q_n}{\partial s} - \mu_c \frac{\partial q_c}{\partial s} \right) &= 0 && (9) \\ -(1 - n_n - n_c)\left(\sigma_c - \mu_c \frac{\partial q_c}{\partial s_c} - \mu_n \frac{\partial q_n}{\partial s} - \mu_c \frac{\partial q_c}{\partial s} \right) &= 0 && (10) \end{aligned}$$

To induce search for both non-commuting and commuting jobs, marginal search costs must increase sufficiently strongly. As we want to focus on a simultaneous search for non-commuting and commuting jobs, sufficient strong convexity is assumed in the study. It is essentially this assumption that distinguishes this study from that of Coulson, Laing, and Wang (2001).

Using the steady-state conditions $\dot{\mu}_j = 0$, $j = n, c$, the first pair of conditions evaluated in the steady state could be summarized as

$$\mu_n - \mu_c = \frac{k}{r + \lambda} \,. \tag{11}$$

Using this condition, the last pair of optimality conditions could be simplified to

$$\sigma_n - \sigma_c = \frac{k}{r + \lambda} \, m \left(\frac{\theta}{s_n + s_c} \right) \,. \tag{12}$$

The difference in marginal search costs for non-commuting jobs and commuting jobs on the left hand side should be equal to the discounted expected value of commuting costs on the right hand side, where the discount rate is adjusted by the separation rate. The higher commuting costs, the more likely a match, or the more secure jobs, the more intensively workers should search for non-commuting jobs compared to commuting jobs.

Solving for the co-state variables, the conditions that determine (constrained) efficient vacancies and search intensities can be written as

$$0 = \epsilon s(p - z + \sigma) - \epsilon k s_c - \frac{s[r + \lambda + (1-\epsilon) q^f \theta] c}{q^f} \,, \tag{13}$$

$$s\sigma_n = \frac{1-\epsilon}{\epsilon} c\theta + s_c \frac{k}{r+\lambda} m \,, \tag{14}$$

$$s\sigma_c = \frac{1-\epsilon}{\epsilon} c\theta - s_n \frac{k}{r+\lambda} m \,. \tag{15}$$

These are the standard conditions corrected for the second opportunity to search.

Finally, in the steady state where $\dot{n}_n = \dot{n}_c = 0$,

$$\frac{s_n}{s_c} = \frac{n_n}{n_c} \,. \tag{16}$$

2.2 Steady State Equilibrium

The present discounted value of the expected income stream of non-commuters and commuters is denoted by J_n and J_c, the value of the unemployed by J_u, and the present discounted value of expected profits of active and inactive firms by J_f and J_v .

In each period, any active firm shares the total surplus with its worker through generalized Nash bargaining taking as given the general wage level and the present values of unemployed workers and inactive firms. For simplicity, we assume that commuters have no bargaining power.[3] Hence, the wage is given by

$$w = \arg\max \left\{ (J_n - J_u)^{\gamma_n} (J_f - J_v)^{1-\gamma_n} \right\} , \tag{17}$$

where γ_n captures exogenously given bargaining power of non-commuters with $0 < \gamma_n < 1$.

Unemployment benefits may depend on search activities such that $b = b(s_n, s_c)$, where partial derivatives are denoted by b_n and b_c. Spending is financed by head taxes τ paid by employed workers.

Steady state equilibrium conditions are

$$rJ_n - [w - \tau + \lambda(J_u - J_n)] = 0, \tag{18}$$

$$rJ_c - [w - \tau - k + \lambda(J_u - J_c)] = 0, \tag{19}$$

$$rJ_u - [z + b - \sigma + q_n(J_n - J_u) + q_c(J_c - J_u)] = 0, \tag{20}$$

$$rJ_f - [p - w + \lambda(J_v - J_f)] = 0, \tag{21}$$

$$rJ_v - \left[-c + q^f(J_f - J_v)\right] = 0, \tag{22}$$

$$\lambda n_n - q_n(1 - n_n - n_c) = 0, \tag{23}$$

$$\lambda n_c - q_c(1 - n_n - n_c) = 0, \tag{24}$$

$$(1 - \gamma_n)(J_n - J_u) - \gamma_n(J_f - J_v) = 0, \tag{25}$$

$$-\sigma_n + \frac{\partial q_n}{\partial s_n}(J_n - J_u) + b_n = 0, \tag{26}$$

$$-\sigma_c + \frac{\partial q_c}{\partial s_c}(J_c - J_u) + b_c = 0, \tag{27}$$

$$\tau(q_n + q_c) - b\lambda = 0. \tag{28}$$

These eleven conditions determine $s_n, s_c, w, \theta, J_n, J_c, J_u, J_f, n_n, n_c$, and τ.

Furthermore, free entry and exit lead to $J_v = 0$. Setting the number of laid off employed equal to the number of hired unemployed, the labor-market-flow-equilibrium conditions (23) and (24) ensure stable employed non-commuting population n_n and commuting population n_c. Equations (18), (19) and (20) are the Bellman equations for non-commuters,

[3] In the appendix, the more general case, where both non-commuters and commuters have some arbitrary power, is briefly discussed.

commuters, and unemployed workers, and equations (21) and (22) are the Bellman equations for active and inactive firms. The outcome of generalized Nash wage bargaining is characterized by equation (25). Equations (26) and (27) are the first-order conditions for optimum (interior) search intensity derived from maximizing rJ_U, when the individual takes aggregate search intensity s as given. Using equations (23) and (24), the government-budget constraint $\tau(n_c + n_n) = b(1 - n_n - n_c)$ can be written as (28).

Due to equation (22), the value of an active firm is $J_f = c/q^f$. Equations (18) and (19) imply that the difference in values of non-commuting and commuting is $J_n - J_c = k/(r+\lambda)$. Using equation (21), the wage can be written as $w = p - (r + \lambda)c/q^f$. Inserting for τ according to the government budget constraint (28), using $J_v = 0$, and solving equations (18) through (22) for J_n, J_c, J_u, J_f, and w, the wage-bargaining condition (25) and the optimum search conditions (26) and (27) characterize the equilibrium with endogenous variables θ, s_n and s_c. In equilibrium,

$$\begin{aligned} J_n - J_u &= \frac{(p - z + \sigma)(q_c + q_n)(r + \lambda) - c\theta(r + \lambda)^2 + kq_c(q_c + q_n)}{(q_c + q_n)(r + \lambda)[r + (q_c + q_n) + \lambda]} \\ &\quad - \frac{b[(q_c + q_n) + \lambda)]}{(q_c + q_n)[r + (q_c + q_n) + \lambda]}, \qquad (29) \\ J_c - J_u &= J_n - J_u - \frac{k}{r + \lambda} \qquad (30) \end{aligned}$$

Eventually, the population variables n_n and n_c can be obtained from equations (23) and (24). Taken together, these equations set the ratio of non-commuters and commuters equal to the ratio of search intensities, as stated by equation (16).

Because the search functions and the wage-bargaining equation are non-linear, the existence of equilibrium with a simultaneous search for non-commuting and commuting types of jobs cannot be proved in general as the existence of this type of equilibrium depends on parameter values. As $m'' < 0$, it can be shown that for any pair (s_n, s_c) of search intensities there exists a tightness measure θ so that the wage-bargaining condition is satisfied provided that $m(0) = 0$ and $\lim_{\theta \to \infty} m(\theta/s) = \infty$.

The difference in optimal (interior) search intensities is determined by

$$\sigma_n - \sigma_c = \frac{k}{r + \lambda} m + b_n - b_c \,. \qquad (31)$$

Hence, in the absence of unemployment benefits, for a given aggregate matching $m\,[\theta/s]$, the difference in search intensities is efficient. Furthermore, higher commuting costs k and a lower separation rate λ imply a greater difference in search activities. More expensive commuting and a more pronounced lock-in effect shift searching towards the region of residence. Furthermore, equation (31) reveals an important property of optimum unemployment benefits stated by the following proposition.

Proposition 1 *To restore differential search efficiency, at the margin, unemployment benefits should subsidize all search activities to the same degree:* $b_n = b_c$*.*

In the absence of unemployment benefits, solving the efficiency conditions for p, and inserting the result into the wage-bargaining condition (25) and the optimum search conditions (26) and (27), it can be shown that the equilibrium is (constrained) efficient if the bargaining power parameter γ_n satisfies

$$\gamma_n \left[1 + \frac{1}{\frac{1-\epsilon}{\epsilon} + \frac{s_c k m}{c\theta(r+\lambda)}} \right] = 1 \,, \tag{32}$$

where the terms within the brackets are evaluated at the constrained optimum. As opposed to the one-region model, $\gamma_n = 1 - \epsilon$ would not be efficient. Workers must have more power than in the one-region model. Furthermore, since J_u depends on the level of unemployment benefits b and optimum search conditions include marginal benefits b_n and b_c, by the right choice of the unemployment benefit *function* the government could restore efficiency even if bargaining power parameters deviate from (32).

Proposition 2 *Suppose that the constrained efficient allocation satisfies equations (13), (14), and (15). (a) There exists a bargaining power parameter* γ_n^* *such that the equilibrium without any government intervention is (constrained) efficient. (b) For* $\gamma_n \neq \gamma_n^*$*, by the choice of an unemployment benefit function* $b(s_n, s_c)$*, the government can always ensure (constrained) efficient search and unemployment.*

Proof. (a) As the term in squared brackets in equation (32) is larger than one, there exists a bargaining power parameter γ_n that fulfills equation (32). (b) Inserting for $J_n - J_u$ and $J_c - J_u$ using equations (29) and (30), the system of equations (25), (26), and (27) is a non-degenerating linear system of equations in b, b_n, and b_c. □

2.3 Commuting subsidies

Commuting subsidies not only affect residence choices, but also extensive and intensive labor supply margins. Suppose that the government subsidizes commuting to the extent of ζ. The government budget constraint must be rewritten as $\tau(n_n+n_c)-\zeta n_c = b(1-n_n-n_c)$. The following conditions should replace their counterparts:

$$rJ_c - [w - \tau - k + \zeta + \lambda(J_u - J_c)] = 0, \tag{33}$$

$$\tau(q_n + q_c) - b\lambda - \zeta q_c = 0. \tag{34}$$

As a consequence, in equilibrium the difference in search intensities is

$$\sigma_n - \sigma_c = \left(\frac{k-\zeta}{r+\lambda}\right) m + b_n - b_c \,. \tag{35}$$

Unemployment benefits must correct for commuting subsidies. Slackening local search should be punished more severely than a decline in search in more distant areas. Otherwise, the unemployed would be biased in their search towards workplaces with long commutes.

2.4 Differentiated wages

By offering free parking or reduced public transport tickets, employers may subsidize commuters. In the model, this could be captured by status-dependent wages. Assuming separated wage bargains and denoting the firm's discounted expected profit from a commuter by J_x, wages are

$$w_n \;=\; \arg\max\left\{(J_n - J_u)^{\gamma_n}(J_f - J_v)^{1-\gamma_n}\right\}\,, \tag{36}$$

$$w_c \;=\; \arg\max\left\{(J_c - J_u)^{\gamma_c}(J_x - J_v)^{1-\gamma_c}\right\}\,, \tag{37}$$

where γ_c indicates the bargaining power of commuters. Leaving commuting subsidies aside, the following conditions replace the respective steady state conditions

$$rJ_n - [w_n - \tau + \lambda(J_u - J_n)] = 0, \tag{38}$$

$$rJ_c - [w_c - \tau - k + \lambda(J_u - J_c)] = 0, \tag{39}$$

$$rJ_f - [p - w_n + \lambda(J_v - J_f)] = 0, \tag{40}$$

$$rJ_x - [p - w_c + \lambda(J_v - J_x)] = 0, \tag{41}$$

$$rJ_v - [-c + q_n(J_f - J_v)/\theta + q_c(J_x - J_v)/\theta] = 0, \tag{42}$$

$$(1-\gamma_n)\,(J_n - J_u) - \gamma_n\,(J_f - J_v) = 0, \tag{43}$$

$$(1-\gamma_c)\,(J_c - J_u) - \gamma_c\,(J_x - J_v) = 0, \tag{44}$$

Equations (38), (39) are the Bellman equations for non-commuters and commuters facing different wages. Equations (40) and (41) are the Bellman equations for firms employing a non-commuter and a commuter, respectively. Equation (42) is the Bellman equation for an inactive firm. Equations (43) and (44) determine the outcome of Nash bargaining with a non-commuter and a commuter.

The wage differential $w_c - w_n$ affects values of firms and workers such that $J_f - J_x = (w_c - w_n)/(r+\lambda)$ and $J_n - J_c = (w_n - w_c + k)/(r+\lambda)$. Wage bargaining implies $J_n - J_c = J_f\gamma_n/(1-\gamma_n) - J_x\gamma_c/(1-\gamma_c)$. For identical bargaining power of non-commuters and commuters, that is, $\gamma_n = \gamma_c = \gamma$,

$$w_c = w_n + k(1-\gamma)\,. \tag{45}$$

Commuters earn more than non-commuters, because they are partially compensated for the additional costs they face.

As

$$\sigma_n - \sigma_c = \frac{km}{r+\lambda}\left[\frac{(1-\gamma_n)\gamma_c s_n + (1-\gamma_c)\gamma_n s_c}{(1-\gamma_n)s_n + (1-\gamma_c)s_c}\right] + \frac{c\theta(\gamma_c - \gamma_n)}{(1-\gamma_n)s_n + (1-\gamma_c)s_c} + b_n - b_c\,, \tag{46}$$

without policy interventions, in general, the difference in search intensities is inefficiently determined. Because vacancy costs should not affect the difference in search intensities, efficiency would require identical bargaining power of non-commuters and commuters, i.e. $\gamma_c = \gamma_n = \gamma$. However, without correcting unemployment benefits, for given m, the difference in marginal search costs is too small: $\sigma_n - \sigma_c = \gamma[km/(r+\lambda)]$. Compensation for commuting costs gives workers incentives so strong that it keeps them from searching efficiently for jobs in their home region. Workers do not take commuting costs fully into account.

Proposition 3 *Suppose that the constrained efficient allocation requires search for non-commuting and commuting jobs and that an equilibrium exists where the unemployed search for both types of jobs. If non-commuters and commuters negotiate separately with employers, the equilibrium will compensate commuters partially for the travel-to-work expenses. As a consequence, without government intervention, the equilibrium is unambiguously inefficient.*

2.5 Asymmetric regions

To analyze heterogeneous regions, we consider an urban region indicated by subscript u and a rural region labeled r. Both regions differ only in terms of productivity. The urban area is more productive than the rural area: $p_u > p_r$. Indicating local tightness measures by θ_i, $i = u, r$, the matching function is written as

$$m = m\left[\frac{\theta_u\,(1-n_{nu}-n_{cu}) + \theta_r\,(1-n_{nr}-n_{cr})}{(s_{nu}+s_{cu})\,(1-n_{nu}-n_{cu}) + (s_{nr}+s_{cr})\,(1-n_{nr}-n_{cr})}\right]$$

The social planner solves

$$\max_{\substack{\theta_u,\theta_s,\\ s_{nu},s_{cu},\\ s_{ns},s_{cs}}} \int_0^\infty e^{-rt} \sum_{\substack{i=u,r\\ j\neq i}} \{p_i(n_{ni}+n_{cj}) + [z - \sigma(s_{ni},s_{ci}) - c\theta_i](1-n_{ni}-n_{ci}) - kn_{ci}\}\,dt \quad (47)$$

taking as given the matching technology and the evolution of employment

$$\dot{n}_{ni} = q_{ni}(1-n_{ni}-n_{ci}) - \lambda n_{ni}, \quad i = u, r, \quad (48)$$

$$\dot{n}_{ci} = q_{ci}(1-n_{ni}-n_{ci}) - \lambda n_{ci}, \quad i = u, r. \quad (49)$$

As the optimization problem is rather complex, it cannot be solved fully analytically. However, optimum search can be partially characterized. In solving the model, it is assumed that search cost functions are sufficiently convex to justify search for all unemployed workers in both regions. Using

$$\mu_{ni} - \mu_{ci} = \frac{p_i - p_j + k}{r+\lambda}, \quad i =, u, r;\ j \neq i, \quad (50)$$

the difference between local and distant search is determined by

$$\sigma_{ni} - \sigma_{ci} = \frac{p_i - p_j + k}{r + \lambda} m, \quad i =, u, r;\ j \neq i, \ . \tag{51}$$

The difference in marginal search costs should cover not only the present value of commuting costs but also that of the difference in productivity. While the urban unemployed should unambiguously search more intensively locally, this is true for rural workers only if commuting costs exceed productivity differences. The difference in search intensities translates into a difference in employment such that $n_{ni}/n_{ci} = s_{ni}/s_{ci}$.

For uniform region-specific wages, the steady state equilibrium conditions for each region with region-specific variables are essentially as stated in the symmetric case if residence based lump sum taxation is assumed: $\tau(n_{ci} + n_{ni}) = b(1 - n_{ni} - n_{ci})$, $i = u, r$. Optimum search intensities are

$$\sigma_{ni} - \sigma_{ci} = \frac{w_i - w_j + k}{r + \lambda} m + b_{ni} - b_{ci}, \quad i =, u, r;\ j \neq i, \tag{52}$$

The equilibrium without search sensitive unemployment benefits would only exhibit efficient differences in search activities if the difference in wages were equal to the difference in prices: $w_u - w_r = p_u - p_r$. As $J_{fi} = (p_i - w_i)/(r + \lambda)$, full worker compensation for productivity differences would require identical active firm values in both regions. For arbitrary bargaining weights, the equilibrium will be generically inefficient.[4] If active firm values and productivity were positively correlated, unemployed workers would search too little in the more productive urban region. As a consequence, urban residents should commute less, rural residents more. To correct for this inefficiency, asymmetric commuting subsidies resp. unemployment benefits should be used.

For differentiated wages, steady state conditions have to be formulated for each region with region-specific variables. No further corrections are necessary. Individually optimal search differences are determined by

$$\sigma_{ni} - \sigma_{ci} = \frac{w_{ni} - w_{ci} + k}{r + \lambda} m + b_{ni} - b_{ci}, \quad i =, u, r;\ j \neq i, \tag{53}$$

[4]It could be shown that the equilibrium would still be inefficient even if vacancy costs were proportional to local prices and commuting costs were proportional to wages.

where w_{ci} indicates the wage faced by a commuter from region i to j. If commuters and non-commuters have equal bargaining power, it can be shown that the wage differential fulfills

$$w_{ni} - w_{ci} + k = \gamma(p_i - p_j + k), \quad i =, u, r; \, j \neq i. \tag{54}$$

As for $i = u$, the right hand side is unambiguously positive and, thus, $w_{nu} - w_{cu} < p_u - p_r$, incentives to search locally are too weak for urban residents. The same is true for rural residents only if $p_r > p_u - k$; otherwise, both urban and rural citizens search too frequently in the rural district. If γ is equal to one, productivity gains would fully accrue to workers implying efficient job search.

The following proposition summarizes the main findings of this subsection.

Proposition 4 *Suppose that the constrained efficient allocation requires search for non-commuting and commuting jobs and that an equilibrium exists where the unemployed search for both types of jobs. If regions differ in productivity, search intensities will be inefficiently chosen in equilibrium. Whether or not wages are uniform within each region, there exist parameter settings so that both rural and urban citizens search too intensively in the less productive rural region. Efficiency enhancing unemployment benefits must take productivity differences and bargaining power of workers into account.*

3 Empirical study

To test the validity of the underlying model, a cross-section analysis of German county data is performed. Using the steady state condition (16) and the condition determining the optimum difference in search intensities, that is, equation (31), the basic model particularly supports the following hypothesis:

H 1 *The larger the ratio of vacancies over the number of unemployed within the labor-market region is, the less workers are ready to commute to another county in the labor-market region.*

According to equation (46), the model with differentiated wages is somewhat ambiguous regarding the vacancy-unemployment ratio. However, both versions predict a negative effect of commuting costs in the event of commuting. With respect to asymmetric counties the model demonstrates a negative effect of higher local wages compared to wages in neighboring counties on commuting. These hypotheses are summarized as follows:

H 2 *The higher the local wage is, the lower the average wage in the labor market region is, and the higher the commuting costs are, the less likely workers out-commute.*

While the predictions regarding the effect of commuting costs and wage differences are quite standard, the inclusion of the vacancy-unemployment ratio is rather unique. Hence, the focus of the empirical study will be on the first hypothesis.

3.1 Data and estimation strategy

Data on 413 German counties (mainly) for 2007 are used for the empirical exercise. Data are provided by the Federal Employment Agency,by the Federal Institute for Research on Building, Urban Affairs and Spatial Development, and by the Federal Agency for Cartography and Geodesy with detailed descriptions are provided in the appendix. The 96 planning regions (Raumordnungsregionen) determined by the Federal Institute for Research on Building, Urban Affairs and Spatial Development will proxy labor market regions. Although the borders of these planning regions are based on commuter flows, they particularly fail to match large labor market regions surrounding the largest cities, as they are designed to be of similar size and not overlap with states. However, this classification is well established and data are readily available. Alternative delineations of labor market regions discussed in the literature show a significantly large variance (Kropp, 2008). Out-commuters at the county level (outcommuter_cty), defined as the share of out-commuters in the regularly employed, constitutes the dependent variable in the regression analysis. In accordance with the model, we focus on gross commuting flows rather than net commuting flows. For example, in the symmetric-regions version of the model, commuting costs affect differences in search intensities, but they do not affect net-commuting flows in equilibrium. Commuting outflows will be regressed on the wage in the county (wage_cty), the labor-market tightness, that is, the ratio of the number of vacancies over the number of unemployed in the county (tightness_cty), the distance (traveling time) to the nearest center of at least order 1 (distance_center), and the squared value of this distance (sq_distance_center). Following central place theory, centers of order 1 determined at the state level provide the surrounding area with certain goods and services. In addition, the centers also serve as local employment centers. Summary statistics for the variables are displayed in table 1.

Variable	Mean	Std. Dev.	Min.	Max.
outcommuter_cty	40.755	13.531	12.2	79.7
wage_cty	2640.388	354.176	1880.5	4124.3
tightness_cty	12.403	8.84	0.8	79.361
distance_center	27.2	18.75	0	79.600
populationgrowth_cty	-0.968	2.886	-10	6.5
share_high_skilled_cty	7.129	3.507	2.4	23.4
share_researcher_cty	8.274	11.288	0	88.600
share_foreigner_cty	7.287	4.663	0.9	26.3
N		413		

Table 1: Summary statistics

We begin with the linear estimation equation:

$$\begin{aligned} \text{outcommuter\_cty}_i \quad &= \quad \beta_0 + \beta_1 \text{ wage\_cty}_i + \beta_3 \text{ tightness\_cty}_i \\ &\qquad + \beta_3 \text{ distance\_center}_i + \beta_4 \text{ sq\_distance\_center}_i + \epsilon_i \end{aligned} \quad (55)$$

3.2 Results and robustness checks

The OLS regression of the model (55) confirms the hypotheses derived from the model. Higher local wages reduce out-commuting and the relationship between distance and out-commuting is hump-shaped. The reason is that for very short distances, the central place is most likely to be located within the boundary of the county rather than outside the county. Most importantly, as predicted by the model, the labor market tightness has a negative impact on the number of commuters. Facing better labor market conditions, workers prefer to work close to home. All variables are highly significant.[5]

[5]Without any substantial effect on the results, we also run an OLS regression where we included population density as an additional control.

dep. var.: outcommuter_cty	OLS	IV
wage_cty	-0.00653**	-0.0131**
	(-2.424)	(-2.567)
tightness_cty	-0.316***	0.409**
	(-2.880)	(2.252)
distance_center	0.528***	0.581***
	(6.458)	(5.969)
sq_distance_center	-0.0107***	-0.0114***
	(-8.442)	(-7.607)
east	-4.533**	-1.418
	(-2.496)	(-0.608)
Constant	60.23***	67.12***
	(8.000)	(5.015)
Observations	413	413
R-squared	0.219	0.063
Overid. [Hansen J]		0.414
Underid. [Kleibergen-Paap rk LM]		0
Weak id. [Kleibergen-Paap rk Wald F]		18.14
Endogeneity		1.68e-05

Robust t statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 2: Regression of commuting flows

As OLS results potentially suffer from a simultaneity bias, we also carry out an IV regression. As instruments for the wage and the labor market tightness we use the geographical position measured by longitude and latitude, population growth from 2002 through 2007 (populationgrowth_cty), and various lagged variables[6], namely the share of high skilled workers (share_high_skilled_cty), the share of workers in research and development (share_researcher_cty), and the share of foreigners in the population (share_foreigner_cty). Using statistical tests, instruments turn out to be relevant and valid, and the regressors are endogenous.[7] Hence, we determine that population growth and population shares are correlated with wages and labor market tightness, but not with the propensity to commute. The inclusion of longitude and latitude improves the R^2, but does not change any sign or statistical significance. Qualitatively, OLS and IV results are similar with one

[6]2003 values are used. However, IV-regressions with contemporary values show similar coefficients and t-values.

[7]Correlation between wage_cty and tightness_cty ist just 0.54, the correlation coefficients for most pairs of instruments are even lower.

dep. var.: outcommuter_cty	SARAR (GS2SLS)	SARAR (ML)	SARAR-IV (GS2SLS)
wage_cty	-0.0136***	-0.0140***	-0.0127***
	(-5.838)	(-6.089)	(-3.168)
tightness_cty	-0.203**	-0.244***	-0.340*
	(-2.000)	(-3.059)	(-1.806)
distance_center	0.650***	0.667***	0.640***
	(9.236)	(8.476)	(8.768)
sq_distance_center	-0.0109***	-0.0112***	-0.0107***
	(-9.459)	(-9.184)	(-9.417)
east	-2.048	-2.320	-2.633
	(-1.112)	(-1.273)	(-1.200)
Constant	64.51***	66.12***	63.69***
	(10.28)	(10.24)	(6.770)
λ	0.684***	0.658***	0.711***
	(4.434)	(7.808)	(4.269)
ρ	0.880***	0.690***	0.922***
	(3.234)	(3.098)	(3.641)
σ^2		105.6***	
		(14.31)	
Observations	413	413	413

z statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 3: Spatially regression of commuting flows

important exception: As opposed to the model's prediction, using instruments, we find that labor market tightness has a significant positive effect on out-commuting. An explanation is that even IV results are biased, as both wage_cty and tightness_cty are highly positively spatially autocorrelated. In part, high local wages and labor market tightness indicators capture similarly high values in neighboring counties which, in turn, promotes out-commuting.

As commuting flows of neighboring regions are simultaneously determined and the delineation of counties and planning regions does not perfectly match functional regions, spatial autocorrelation in the data should be expected. Indeed, Lagrange multiplier tests reject the hypothesis of absent spatial lags in disturbances and in the dependent variable. Hence, to take spatial autocorrelation appropriately into account, we estimate a spatial autoregressive model with spatial autoregressive disturbances (SARAR) both with a generalized spatial two-stage least-squares (GS2SLS) estimator and with a maximum likelihood estimator (ML). GS2SLS allows for heteroskedasticity, ML does not.[8] As a spatial weighting matrix, we use a min-max normalized truncated inverse distance matrix.[9] Qualitatively, the spatial regressions confirm the OLS results. Signs of coefficients and statistical significance do not change. Even quantitatively, there are only minor differences between the OLS and the SARAR. After controlling for spatial autocorrelation in dependent variables and disturbances, the labor-market-condition indicator tightness_cty has the predicted sign and is significant. To solve for endogeneity, a spatial IV regression – using the same instruments as before – is estimated. Interestingly, the spatial IV model comes close to OLS.

Since the model predicts that the local wage relative to neighboring region's wages determines the benefit from commuting, we add the spatially lagged wage (sl_wage_cty) to the RHS of our model (55) and estimate it with OLS and SARAR (ML). Furthermore, as the theoretical model is only about commuting within labor-market regions we also include net-commuter flows at the labor-market level, that is, out-commuters minus in-commuters, at the planning region level (netoutcommuter_ror), despite potential endogeneity, as a control. However, the results are robust to this modification of the model and the lagged variable has the expected influence on out-commuting. While an increase in the local wage reduces the incentive to commute, the wage at the regional level is a pull factor. Larger net-commuting flows out of the entire labor market region also increase out-commuting at the county level. Notably, including spatially lagged wages turns λ from positive to negative. The reason may be that spatial autocorrelation of commuting flows is positive at a larger spatial scale beyond metropolitan areas, but negative within metropolitan areas as the latter induced by commuting flows from rural areas to agglomeration centers. Due to large spatial wage clusters, sl_wage_cty indirectly also measures large-scale commuting clusters, implying that λ basically measures negative spatial autocorrelation in commuting flows caused by suburban-urban traffic flows.

[8]For further information of these estimation procedures and the implementation, see Arraiz, Drukker, Kelejian, and Prucha (2010); Drukker, Egger, and Prucha (2010); Kelejian and Prucha (1998, 1999, 2004, 2010).

[9]Not presented, we run our regressions for varying truncation levels. As long as there are not too few neighbors, results do not change.

dep. var.: outcommuter_cty	OLS	OLS	SARAR (ML)	SARAR (ML)	SARAR-IV (GS2SLS)
wage_cty	-0.0138***	-0.0111***	-0.0147***	-0.0132***	-0.0164***
	(-6.024)	(-4.542)	(-7.339)	(-6.757)	(-5.772)
tightness_cty	-0.143	-0.137	-0.203***	-0.207***	-0.329**
	(-1.558)	(-0.924)	(-2.842)	(-2.983)	(-2.122)
sl_wage_cty	0.0128***	0.0119***	0.0253***	0.0238***	0.0255***
	(11.44)	(8.342)	(9.349)	(11.41)	(7.227)
distance_center	0.563***	0.583***	0.605***	0.609***	0.521***
	(7.802)	(6.319)	(9.007)	(9.472)	(8.178)
sq_distance_center	-0.00952***	-0.0101***	-0.00956***	-0.00990***	-0.00866***
	(-8.420)	(-7.685)	(-8.997)	(-9.702)	(-8.656)
east	-0.737	-0.352	3.357*	3.400*	-0.422
	(-0.447)	(-0.190)	(1.700)	(1.712)	(-0.194)
netoutcommuter_ror		2.121***		2.140***	
		(3.351)		(4.970)	
Constant	63.50***	53.95***	59.95***	54.05***	68.00***
	(10.13)	(8.608)	(10.39)	(9.532)	(9.073)
λ			-0.495***	-0.557***	-0.320**
			(-4.256)	(-5.262)	(-2.442)
ρ			2.076***	2.367***	1.617***
			(18.31)	(66.33)	(4.955)
σ^2			80.57***	75.57***	
			(14.36)	(14.36)	
Observations	413	413	413	413	413
R-squared	0.413	0.450			

OLS: Robust/clustered t statistics in parentheses
SARAR: z statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Regression of commuting flows including spatially lagged wages

4 Concluding remarks

Employing a standard matching unemployment model extended by within-labor-market-regions commuting, this paper analyzed the tradeoff of commuting costs and unemployment. Depending on whether commuters are able to bargain for fringe benefits, employment search may or may not be biased towards distant workplaces and/or low-productivity regions. As a consequence, unemployment benefits should be tied more strongly to searches in high productivity regions. Using German county data, the paper tested main predictions of the model. In particular, it confirmed that increasing labor market tightness reduces the willingness to commute to neighboring districts.

The model could be extended in serval ways. Most importantly, migration should be introduced. Second, worker heterogeneity and sorting should be considered. Moreover, cross-labor-market-region commuting could be added. However, these possible extensions are left for future research. Furthermore, once the diagnostics for the spatial IV-regression are available, they should be included into the empirical analysis. Finally, the dynamic dimension of unemployment should be addressed, in particular, as Patuelli, Schanne, Griffith, and Nijkamp (2011) have found widely heterogeneous, but generally highly persistent regional unemployment rates at the county level in Germany.

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Appendix

Powerful commuters when the wage is uniform

If commuters have some power in the uniform-wage bargaining process, that is, $\gamma_c > 0$, with $0 < \gamma_n + \gamma_c < 1$, the uniform wage in symmetric regions is determined by

$$w = \arg\max \left\{ (J_n - J_u)^{\gamma_n} (J_c - J_u)^{\gamma_c} (J_f - J_v)^{1-\gamma_n-\gamma_c} \right\} .$$

Hence, the wage-bargaining condition (25) becomes

$$\frac{\gamma_n}{J_n - J_u} + \frac{\gamma_c}{J_c - J_u} - \frac{1 - \gamma_n - \gamma_c}{J_f - J_v} = 0 \,.$$

As the wage-bargaining equation is highly non-linear, the existence of an equilibrium cannot be proved in general as existence depends on parameter values. The condition for efficiency-ensuring bargaining-power parameters (32) reads

$$\gamma_n \left[1 + \frac{1}{\frac{1-\epsilon}{\epsilon} + \frac{s_c k m}{c\theta(r+\lambda)}} \right] + \gamma_c \left[1 + \frac{1}{\frac{1-\epsilon}{\epsilon} + \frac{s_n k m}{c\theta(r+\lambda)}} \right] = 1,$$

where the terms within the brackets are evaluated at the constrained optimum. The stronger the bargaining power of non-commuters, the less powerful commuters should be. However, while equations (26) and (27) are still linear in b_n and b_s, respectively, and in b, the wage-bargaining equation is quadratic in b. Hence, a solution may not exist. As a consequence, the statement (b) in proposition 2 requires some reservation: If the power distribution does not fulfill the above condition, the government can only ensure efficient search and unemployment if the wage-bargaining equation has a solution in b after p has been solved for the optimum vacancy equation (13).

For asymmetric regions, the wage-bargaining condition must be written as

$$\frac{\gamma_n}{J_{ni} - J_{ui}} + \frac{\gamma_c}{J_{cj} - J_{uj}} - \frac{1 - \gamma_n - \gamma_c}{J_{fi} - J_v} = 0, \quad i =, u, r;\ j \neq i,$$

as non-commuters and commuters living in different regions must be taken explicitly into account.

Empirical analysis: variables

- outcommuter_cty: share of out-commuters in regularly employed workers in % (2007).
- wage_cty: gross wage per employee in Euro (2007).
- distance_center: travel time to the next upper-level central place in minutes; values at the county level are area-weighted averages of all values at the community level.
- number of vacancies and number of unemployed at the county level are used to calculate tightness_cty.
- populationgrowth_cty: population growth from 2002 through 2007 in %.
- share_foreigner_cty: share of foreigners in the population in % (2003).
- share_researcher_cty: share of workers in research and development in regularly employed workers in % (2003)
- share_high_skilled_cty: share of workers with tertiary education in regularly employed workers in % (2003)

Empirical analysis: sources

- Provided by Federal Institute for Research on Building, Urban Affairs and Spatial Development via INKAR 2010 and INKAR 2009: outcommuter_cty, wage_cty, distance_center, populationgrowth_cty, share_foreigner_cty, share_researcher_cty, share_high_skilled_cty.
- Provided by the Federal Employment Agency: number of vacancies and number of unemployed.
- Provided by the Federal Agency for Cartography and Geodesy: latitude and longitude.

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