Regional Labor Markets and Aging in Germany

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Abstract

This paper analyzes how the aging labor force affects the unemployment rate at the regional level in Germany. A theoretical model of equilibrium unemployment with spatial labor market interactions is used to study the effects of age-related changes in job creation and job destruction. Using data for 343 districts, we then examine empirically the consequences of an aging labor force for the local labor markets in Germany. We apply different estimation techniques to a spatial and time dynamic panel data model. According to the estimates, aging causes an increase in job destruction. In addition, aging in the local labor market increases job creation, while the spatial aging effect on job creation in the local district is negative.

Keywords: Regional Unemployment, Vacancies and Separations, Job Creation, Regional Mobility, Spatial Interactions and Matching, Aging of the Labor Force, Spatial Econometrics

JEL classification: J64, J63, J23, J61, R12, J10, C23

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1 Introduction

Does population aging and, hence, the aging of the labor force affect the labor market and, ultimately, unemployment? In other words, do birth cohorts; e.g., baby boomer and baby buster, differ from each other in their employment relevant attributes apart from cohort size? Although population aging is a well-known fact, the effects of aging on employment and unemployment are not fully discovered. This paper analyzes the impact of an aging workforce on job creation, job destruction, and on equilibrium unemployment in regional labor markets with spatial interactions.

Even in the labor market, sizeable differences in the size of birth cohorts (e.g., baby boomer vs. baby buster) are visible in many industrialized countries. For example, during the 1980s and 90s, the ratio of young to old people in the labor force (here between 15 and 39 years old to those between 40 and 64 years old) declined from 1.8 to 1.1 in Canada, from 1.2 to 0.9 in Germany, from 1.3 to 0.9 in Japan and from 1.6 to 1.1 in the USA. Within countries, however, large differences at the regional level exist as well. For example, using German data from 2000 and 2001 at the district level (343 regions), we find a range of 1.5 to 0.6 for the ratio of young to old workers.

In most cases, the literature dealing with age and employment or matching is related to specific issues. Pissarides and Wadsworth (1994) and Burgess (1993) find evidence for Great Britain that the rates of job separation are higher for young workers because a higher proportion of them conduct on-the-job searches.[1] Hence, matching may decrease with an older working population as Coles and Smith (1996) argue in their study for England and Wales. Job separations and low hiring rates for older workers could be the result of age discrimination (Johnson and Neumark 1997, Charness and Villeval 2007) and pretended or actual productivity differentials (Haltiwanger et al. 1999, Daniel and Heywood 2007). Productivity may increase with age if job experience is important (Autor et al., 2003) or decline if human capital depreciates over a lifetime, particularly due to technological change or a loss of manual abilities (Bartel and Sicherman 1993, Hellerstein et al., 1999, Börsch-Supan 2003).

Employment effects may also stem from differences between the age-earning profile and the age-productivity profile, for which Lazear (1979) and Hutchens (1987, 1989) provide empirical evidence. According to these findings, earnings increase with age more than productivity grows. Firms receive benefits from this productivity-wage differential if employees are young, but the benefits reduce with their age and might even become negative. Consequently, firms may opt to get rid of their older employees, and aging of the labor force may be the reason for an increase in the total number of

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[1] Davis et al. (1996) find evidence for the US that job flows are higher for young workers.

dismissals.

The willingness to create new jobs is expected to change not only because of variations in the cohort sizes and average labor productivity, but also because of expected changes in mobility in an aging labor force. According to Brücker and Trübswetter (2007) and Hunt (2000), regional mobility decreases as age increases. This applies to high- and low-skilled workers as well as for employed and unemployed people. The causes for this decreasing mobility after a certain point in life are, for example, housing tenure, partner's economic status, and childcare.[2]

Another important issue in the context of mobility is that of spatial dependencies of the regional labor markets. The performance of a local labor market depends, among other things, on the characteristics of the regional labor markets in the surrounding area. For example, job creation can be affected in different ways depending on the age structure of the labor force in the neighbor districts, since age-related regional mobility exhibits strong distinctions. Although it seems obvious that regional mobility plays an important role at the regional level, only a few studies consider spatial labor market interactions. Fahr and Sunde (2005) use data at the regional level for West Germany and estimate a matching function. They allow for spatial mobility of the unemployed but do not consider spatial interaction in job creation. Their results indicate that matching is positively related to young participants in the labor market. Hujer et al. (2007) extend this approach and allow for spatial dependencies of unemployed and vacancies in their matching function. However, in contrast to Fahr and Sunde (2005), they focus exclusively on active labor market program participants. According to their results, an increase in unemployment in the surrounding areas increases matching in the local region, while the opposite is true for the vacancies.

Hence, age-related productivity, separation, mobility, and spatial labor market interactions can affect the matching equilibrium of local labor markets in different ways. From this, it follows that a definite conclusion concerning the effects of aging on unemployment is very difficult. A simple way to estimate the effects of the age structure on unemployment is the shift-share approach. An example is Shimer (1998), who attributes changes in US unemployment to variations in the population shares of age groups with low and high age-specific unemployment rates. However, this approach does not consider age-related changes in labor demand. Shimer (2001) and Nordström Skans (2005) estimate the impact of changes in the population share of the young (age 16 to 24) on unemployment. In their analysis of US and Swedish local labor markets, respectively, they find that unemployment tends to be lower if many young people supply labor. Shimer (2001) argues that a high proportion of young workers is an incentive for firms to create new jobs because younger workers undertake more search activities, which

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[2]See, for example, Lindley et al. (2002) for a detailed discussion of these causes.

reduce the recruitment costs for firms. The paper most closely related to this is Hetze and Ochsen (2006), who extend the standard Pissarides (2000) model of equilibrium unemployment by two age groups. To capture the demographic effects empirically, they estimate both the Beveridge curve and the job creation curve using aggregate data for 12 OECD countries. They find, for example, that an aging labor force may cause a rise in unemployment in Germany, while the US experienced positive employment effects from an increase in the share of workers age 40 and older.

The following analysis, undertaken to identify the demographic effects on equilibrium unemployment, provides theoretical implications and empirical findings for the German labor market. First, we extend the standard model of equilibrium unemployment by on-the-job search, two age groups, and regional labor market interactions. Age-related effects are introduced with the consideration of an assumed productivity differential between the two groups and with age-specific separation risks. Spatial interactions between neighborhood regions are implemented in such a way that it affects both job creation and job destruction in the local region. The matching equilibrium results in four different labor market regimes of an aging labor force with different combinations of changes in the Beveridge curve and job creation. Only in two regimes is the demographic impact on unemployment clearcut. Because of spatial interactions, aging in the surrounding regions can exacerbate or mitigate the effects that emerge within a local region.

Using data for 343 districts, we then examine empirically the consequences of an aging labor force for the local labor markets in Germany. We estimate both the Beveridge curve and the job creation curve, applying different estimation techniques to a spatial and time dynamic panel data model (including an estimator as suggested by Lee and Yu (2007)). The data used are monthly and cover the years 2000 and 2001. We use firm-level data and aggregate them to the regional level, and combine them with regional data provided by the Federal Statistical Office. According to the estimates, ongoing aging in the local labor market will cause an increase in job destruction. In addition, aging in the local labor market increases job creation, while aging in the surrounding areas has a negative effect on job creation in the local district, which is larger in magnitude. Hence, the results imply that unemployment further increases when the share of younger job seekers continuously decreases in the local and the surrounding areas. This applies in particular to the Eastern German regions.

The remainder of the paper is organized as follows. In section 2, we model equilibrium unemployment under the assumption of on-the-job search, age-related heterogeneity in the labor force, and spatial interactive labor markets. Section 3 presents the econometric model and reports the estimation results. Finally, we summarize our results in section 4.

2 Theoretical Model

The modeling of search and equilibrium unemployment in this section includes a simplified consideration of on-the-job search. In addition, we introduce aging of the labor force and spatial dependencies of regional labor markets in the theoretical framework. With respect to spatial dependencies, this is the first paper to consider spatial interactions in an equilibrium unemployment model. In contrast to Fahr and Sunde (2005) and Hujer et al. (2007), our underlying matching function allows for on-the-job search. The modality of introducing spatial dependencies allows for movements both of and along the Beveridge curve.

To retain simplicity, we introduce on-the-job search differently from the standard framework (see Pissarides, 2000). First, we do not consider the two usual reservation productivity parameters that allow differentiation between productivity related job destruction and on-the-job search. In general, this helps to explain why employed people decide in favor of on-the-job search. The focus in this paper, however, is on the consequences of spatial search activities on job creation and job destruction. Second, we neglect search costs for on-the-job seekers. On the one hand, we expect that they are sufficiently small, and thus negligible. On the other hand, the standard on-the-job search model does not consider search costs for the unemployed, which seems to be somewhat unrealistic when regional mobility is considered. Instead, to introduce these costs for both, we neglect them in the theoretical part of the paper. Search costs are not crucial for the general conclusions in this paper. Moreover, from an empirical perspective, we are unable to consider search costs.

With respect to aging of the labor force, we follow the modeling of Hetze and Ochsen (2006) and extend the framework of search and equilibrium unemployment with the distinction between younger and older workers, and age-related effects on job creation and job destruction.[3] The standard model implies that regions with an older labor force will have lower unemployment rates. This is due to the simple assumption that young workers are born into unemployment. In contrast to this, we ignore "births" and "deaths" in the labor market, but analyze the effects on equilibrium unemployment if younger and older workers differ in some individual characteristics. From this, it follows that changes in the age structure can have ambiguous effects on unemployment. We differentiate between younger and older workers who may generate different levels of surplus for firms if they fill a vacancy, by considering age-sensitive differentials in labor productivity, separation risks,

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[3]We analyze the effects of aging of the labor force but ignore the effects of a population decline. The reason for this is that most empirical studies find constant returns to scale of matching functions. Petrongolo and Pissarides (2001) provide an overview of the related literature. Therefore, the pure population size has no effect on matching and search equilibrium in the labor market.

wages, and mobility. The purpose of the environment is to be general enough to catch the different ways in which shifts in the age composition can affect equilibrium unemployment via job creation and job destruction. Due to the generality, we can apply our theoretical results to an econometric model in section 3 to analyze how aging affects unemployment.

This study considers two types of agents, workers and firms. All agents are risk neutral and discount the future at rate r. From the individual attributes, i, of workers, we consider age as the only relevant factor here. The labor force is divided into two age groups, which have a share of p and $(1 - p)$ respectively, henceforth identified as the younger workers, y, and the older workers, o. Workers are either employed or unemployed, in which case, they seek a new job. The average rate of unemployment u in a continuum of workers, normalized to 1, then consists of the age-specific rates weighted at the relevant population share, $u = pu_y + (1 - p) u_o$.[4]

Search frictions limit the matching of job seekers and vacancies. New employment relations are created through a matching technology, which forms the number of matches from the number of unemployed workers, the number of on-the-job searchers, and the number of vacancies. That is, the standard matching technology is enlarged by a rate e of the employed, who search on-the-job for new employment. Hence, $m = m(u + e, v)$ is the flow rate of matches formed, with v denoting the vacancy rate.[5]

Equilibrium in search models usually depends on the tightness of the labor market defined as $\theta = v/(u + e)$, because θ determines how successful search is. A firm with a vacancy meets a job seeker at a rate $q(\theta) = m(u + e, v)/v$, thus decreasing with the vacancy-unemployment ratio. A job seeker finds a new employment at rate $\theta q(\theta)$, which is identical for both age groups, as advertised vacancies do not differentiate between younger and older candidates. That is, it is assumed that the matching technology is random in the sense that if the proportion of younger people in the labor force is p, then the conditional probability that a vacancy is filled with a younger worker is p as well.

The job finding rate $\theta q(\theta)$ is related to a closed labor market. At the regional level, however, it is obvious that people apply for jobs in surrounding regions. According to the Federal Office for Civil Engineering and Regional Development in Germany, about 55% of employed people commute between the home region and the workplace region. In addition, the bulk of these commuting dependencies applies to regions that share the same border. To maintain the model's simplicity, we consider matching relevant job seekers and vacancies only from the local region l and those regions that share

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[4]Let L denote the labor force and L_y and L_o represent the respective age-related size of the labor force. The unemployment rate weighted by the age groups is determined by $u = \frac{U_y}{L} + \frac{U_o}{L} = \frac{L_y}{L_y}\frac{U_y}{L} + \frac{L_o}{L_o}\frac{U_o}{L} = pu_y + (1 - p) u_o$.

[5]As standard, $m(u + e, v)$ exhibits constant returns to scale in its arguments, is continuous and differentiable, and $m(u + e, v) < \infty$.

the same border with the local region. In addition, we treat the neighbor regions as one homogenous region, n. Now, the local labor market tightness is given by $\theta^l = v^l / \left(u^l + e^l + u^n + e^n \right)$, and the neighbor district labor market tightness is equal to $\theta^n = v^n / \left(u^n + e^n + u^l + e^l \right)$.

To consider the age-related mobility differences we pose the following argument. Every job seeker applies for jobs in the home region, but the number of regional mobile job applicants depends on the age structure of the job seekers. That is, a local firm with a vacancy meets a job seeker at a rate $q^l \left(\theta^l, p^n \right)$, with $\partial q^l / \partial p^n > 0$. This means that for a given number of job seekers in region l and n, it will be easier for local firms to find an appropriate applicant if a higher number of younger job searchers are in the surrounding labor market, n. From the perspective of the local labor market, a job seeker finds, on average, new employment at the rate $\theta^l q^l \left(\theta^l, p^n \right) + \theta^n q^n \left(\theta^n, p^l \right)$.

Job-worker matches have a finite time horizon. Separation occurs because of idiosyncratic shocks that hit all matches at the same probability s. In addition to this, age-related shocks are possible. Let τ_o and τ_y denote the rates which indicate the added risk that the match ends as the worker is older or younger. The rates may also include different quitting rates (labor turnover rates) because of, for example, differences in regional mobility.[6] Finally, from the perspective of the local region, we must add the probability that a mobile worker loses his job in the surrounding area, $\alpha \left(s + \tau_i \right)$. Here, α is the share of mobile workers employed in the neighbor district, n.

The unemployment rates of younger and older workers evolve according to job creation and job destruction, with $i = [y, o]$:

$$
\begin{aligned}
\dot{u}_i^l = {} & \left(s + \tau_i \right) \left(1 - u_i^l \right) + \alpha \left(s + \tau_i \right) \left(1 - u_i^n \right) \\
& - \theta^l q^l \left(\theta^l, p^n \right) u_i^l - \theta^n q^n \left(\theta^n, p^l \right) u_i^l.
\end{aligned}
\tag{1}
$$

The first term on the right-hand side is the age-related flow into unemployment from a local employment. The second term comprises the age-related flow into local unemployment from jobs in the neighbor region, n. To simplify the conclusions, we assume that separation rates are equal in the local and neighbor region. The third and fourth terms are the transition probabilities into a new job in the local and neighbor labor market.

From $\dot{u}_i = 0$ it follows that the age-specific rate of equilibrium unemployment in the local labor market is

$$
u_i^l = \frac{\left(1 + \alpha \right) \left(s + \tau_i \right) - \alpha \left(s + \tau_i \right) u_i^n}{s + \tau_i +^l \theta^l q \left(\theta^l, p^n \right) + \theta^n q^n \left(\theta^n, p^l \right)}.
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[6] According to the Federal Employment Office in Germany, younger job seekers exhibit higher regional labor market mobility than older people. However, the difference is lager for the unemployed than for on-the-job seekers.

The summation of the two unemployment rates weighted at the respective local population proportions, p^l and $(1 - p^l)$, then yields the local Beveridge curve (BC)

$$u^l = \frac{(1 + \alpha)(s + \tau_o) - \alpha(s + \tau_o) u_o^n}{s + \tau_o + \theta^l q^l (\theta^l, p^n) + \theta^n q^n (\theta^n, p^l)} + p^l \left(u_y^l - u_o^l \right). \tag{2}$$

This is the local BC plus spatial and aging effects. The local age-related effect in the first term on the right hand side disappears if the separation rate is identical for younger and older workers. Otherwise, an increasing proportion of the age group with the higher separation rate increases job destruction and unemployment. The second term on the fraction stroke means that the positive flow of newly unemployed from the surrounding region decreases the higher the unemployment rate in this region. This spatial effect disappears if the interregional flows cancel each other out. The proportion of older and younger workers in both the local and the surrounding labor market is of importance for the local unemployment rate. However, the spatial aging effect is hidden in the local reemployment probability q^l. The second term in eq. (2) is the direct effect of local labor force aging via age-specific unemployment rates. Finally, the unknown θ's in BC determine equilibrium unemployment, and they are explained by the willingness of firms to create vacancies.

The number of vacancies depends on the decisions made by firms. A firm can be in one of the three states: It is inactive at zero return, it seeks a worker at search costs, or it hires one worker, starts production, and earns a profit. Vacancies are open equally to younger and older workers. That is to say, we do not consider age discrimination in conjunction with the advertisement of a vacancy.

Whether local firms create new jobs or remain inactive is subject to the benefits they receive and the costs they must pay during their market activities. The benefits and costs include the (present-discounted) value of the states: Match with an older worker J_o, match with a younger worker J_y, and unfilled vacancy V. The values satisfy the Bellman equations

$$rJ_o = \mu - w_o - (s + \tau_o)(J_o - V), \tag{3}$$

$$rJ_y = \mu + \delta - w_y - (s + \tau_y)(J_y - V), \tag{4}$$

$$rV = -\gamma + q^l \left(\theta^l, p^n \right) (V - J). \tag{5}$$

Firms receive revenues μ from selling the output if an older worker is employed, while they pay the wage w_o as compensation. The younger worker produces the value $\mu + \delta$ and earns w_y. Experience and lower training costs favor older workers but a lower depreciation of human capital is an argument for the higher productivity of younger workers. Hence, we do not fix the sign

of the output differential, so that $\delta \gtreqless 0$.[7] The job-worker match ends at the probability $s + \tau_i$, in which case the value of the match is replaced by the value of an unfilled vacancy.

The vacant job costs γ per unit time and changes state according to the Poisson Process at rate $q^l \left(\theta^l, p^n \right)$. Hence, given that younger workers are favored, an increase in the share of younger workers in the surrounding area increases the number of vacancies in the local labor market. The change of state yields net return $J - V$, with J denoting the expected value of a filled vacancy. As the firm can meet two types of workers, we consider that the worker is younger at probability p, and he is older at probability $(1 - p)$. The share, p, is the proportion of younger people in the labor force of the considered regions; that is, the local and the surrounding area. Since regional mobility affects p positively, it is underestimated in this definition. However, in the empirical part of the paper we cannot control for the mobility corrected age distribution. Therefore, we ignore that aspect here.

Local and spatial age-related supply effects are considered in p, and the expected value of filling the vacancy is

$$J = pJ_y + (1 - p) J_o. \tag{6}$$

As revenues exceed costs in any case, a job-worker match is always more profitable than a vacant job. However, workers have an impact on the equilibrium outcome through their roles in wage determination. The employment of an older or a younger worker is expected to provide different returns to the firms. Hence, employment should be related to different income for the two types of workers, w_o and w_y.

The unemployed job seekers receive some real return, b, which is usually an unemployment benefit. As these payments have no age-sensitive elements in Germany, we assume the same rate, b, for older and younger job seekers. Let U and W denote the present-discounted value of the expected income stream of an unemployed and an employed worker, respectively. The unemployed get benefits, b and in unit time, they can expect to move into employment at the probability $\theta^l q^l + \theta^n q^n$. In this case, they gain W but lose U. On average, the chance to find employment is equal for older and younger workers, as firms do not advertise age-segregated vacant jobs.

The permanent income of employed workers is different from the constant wage as the match ends for an individual at probability $s + \tau_i$ and the status changes from W to U.[8] Hence, age-related individuals can expect benefits

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[7] See Börsch-Supan (2003) and Hutchins (2001) on the difficulty of the measurement of individual age-related productivity.

[8] As mentioned in the beginning of this section, we do not consider on-the-job search costs. This is because search costs are not crucial for the general conclusions in this paper. One way to introduce these costs would be to allow for search costs in the case of spatial search of both the employed and unemployed. However, the results are very intuitive, because this reduces spatial mobility.

from labor supply which satisfy

$$rU_i = b + \left[\theta^l q^l \left(\theta^l, p^n\right) + \theta^n q^n \left(\theta^n, p^l\right)\right] (W_i - U_i) \tag{7}$$

during job search as unemployed and

$$rW_i = w_i + (s + \tau_i) (U_i - W_i) \tag{8}$$

if they are employed. We do not differentiate between employed who search for a new job and those who do not. The differences between w_o and w_y reflect that older and younger workers can be of different value for a firm. Differences in the risk of separation $\left(\tau_o \lesseqgtr \tau_y\right)$ affect the probability of a change of state towards unemployment and consequently, the expected values of W_i and U_i.[9]

2.1 Equilibrium

We now must determine the market tightness in the local region and, hence, equilibrium job creation. This is necessary to derive a conclusion from a change in the age structure of the labor force on equilibrium unemployment. To do this, we first need to determine wages and the pooling condition. Wage determination must specify the labor costs so that firms can evaluate the actual value of filling a vacancy. The pooling condition satisfies that vacant jobs do not distinguish between older and younger workers.

Wages are derived from the Nash bargaining solution (for details, see the Appendix). While the worker gains W_i but loses U_i if she starts a new job from unemployment, the firm gives up V for J. The share of the total benefits each party receives depends on a measure β, which is usually interpreted as the bargaining power of the workers:

$$w_o = \frac{(1 - \beta) b + \beta \mu \left[1 + \frac{\theta^l q^l(\cdot) + \theta^n q^n(\cdot)}{r + s + \tau_o}\right]}{1 + \beta \frac{\theta^l q^l(\cdot) + \theta^n q^n(\cdot)}{r + s + \tau_o}}, \tag{9}$$

$$w_y = \frac{(1 - \beta) b + \beta (\mu + \delta) \left[1 + \frac{\theta^l q^l(\cdot) + \theta^n q^n(\cdot)}{r + s + \tau_y}\right]}{1 + \beta \frac{\theta^l q^l(\cdot) + \theta^n q^n(\cdot)}{r + s + \tau_y}}. \tag{10}$$

Employed workers receive pay between income during job search (b) if $\beta = 0$ and the total revenues generated by the employment ($\mu, \mu + \delta$) if $\beta = 1$. Values of β between zero and unity consider a twofold effect of a higher probability of reemployment $\theta^l q^l (\cdot) + \theta^n q^n (\cdot)$. First, the lower bound of bargaining outcome increases with $\theta^l q^l (\cdot) + \theta^n q^n (\cdot)$ because it is easier to

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[9]As usual, we assume that $w_i > b$ and workers do not give up their jobs due to a higher alternative income.

find another vacant job and the threat level that the application for a job is rejected is lower. Second, the upper bound decreases with $\theta^l q^l(\cdot) + \theta^n q^n(\cdot)$ because firms must wait longer until they can fill a vacant job. This reduces the total benefits from market activities that can be shared among firms and workers.

While a vacant job generates zero revenue ($V = 0$), the filled vacancy has a positive value for a firm. In consideration of the age-related wages, it then follows from eq. (3) and eq. (4) that the value of employing an older worker is

$$J_o = \frac{(1 - \beta)(\mu - b)}{r + s + \tau_o + \beta \left[\theta^l q^l(\cdot) + \theta^n q^n(\cdot)\right]}, \tag{11}$$

whereas the younger worker generates a value of

$$J_y = \frac{(1 - \beta)(\mu + \delta - b)}{r + s + \tau_y + \beta \left[\theta^l q^l(\cdot) + \theta^n q^n(\cdot)\right]}. \tag{12}$$

The dissimilarity in the equations implies that firms may prefer to meet a younger or an older job seeker if they have a vacant job. One age group can have a higher productivity-wage ratio or a lower quitting rate so that it is more valuable to hire workers from this age group. However, firms also know that the search will continue and cause further costs if they refuse a job candidate. The candidates are stochastically drawn from the pool of job seekers and are younger at probability p and older at probability $(1 - p)$. If the drawing brings the inferior candidate and the firm rejects the employment, the firm expects to pay γ over an additional period. Therefore, firms will accept the first applicant for work as long as extra costs of rejection are equal to the extra gain through employing a superior worker. In this case, the expected value of a vacancy is zero because waiting is worthless. This holds true if $J = \gamma/q(\theta)$ and with eq. (6), the equation for the expected J, we have:

$$J_o = \frac{1}{1 - p}\left(\frac{\gamma}{q^l(\cdot)} - pJ_y\right). \tag{13}$$

This is the condition for a pooling equilibrium in which vacancies are open to both younger and older job seekers. Market tightness is the only parameter that is variable, and it guarantees the identity of eq. (13). Rearranging yields the second important equation, the job creation condition:

$$\frac{1}{q^l(\cdot)} = \frac{\mu - w_o + p\delta}{\gamma(r + s + \tau_o)} \tag{14}$$

The vacancy-matching ratio $1/q^l(\cdot)$ is an indicator of local job creation. Firms open more vacancies if $1/q^l(\cdot)$ increases. It is obvious that easy

search and high profits foster job creation. Age-related separation and productivity differences have clear effects on job creation. In addition, we see that if the number of on-the-job searchers increases, either from the local or from the neighbor region, this also increases job creation. This is caused by a reduction of search costs. In addition, job creation could decrease if aging happens in the surrounding area. This is because of the negative regional mobility effect of aging in the surrounding area. This effect is independent from the productivity and separation differences of older and younger workers. Hence, it is possible that firms favor older workers, but the overall effect of aging is negative if aging happens in the local and the neighbor region. In this case, the positive effect of the employment characteristics of older workers will be outweighed by the effect of a decreasing number of applicants.

Steady state equilibrium on the local labor market satisfies the flow equilibrium (2), the job creation condition (14), and the two wage equations (9) and (10). Job creation and the wage equations yield market tightness. Together with the BC equilibrium unemployment is fixed.

2.2   Effects of Aging

The aging of the labor force affects local equilibrium unemployment if older and younger workers differ in the considered attributes, and if it affects the number of regional mobile job seekers. Hence, next we analyze the comparative static effects of a change in the share of younger workers (p) on equilibrium in the local labor market. We do not assume that younger or older people in local and neighbor regions are different in their employment characteristics. Moreover, we are particularly interested in the differences between the younger and older workers who supply labor to the local labor market.

From the job creation condition it follows that the market tightness responds to a change in p according to:

$$\frac{\partial \left(\frac{1}{q^l(\cdot)} \right)}{\partial p} = \frac{1}{\gamma} \left(J_y - J_o \right). \tag{15}$$

The willingness to create a vacancy, $1/q^l(\cdot)$, decreases (increases) due to a fall in p if $J_y > J_o$ ($J_y < J_o$). The age structure has no effect on job creation under the assumption that $J_y = J_o$. This means that different age-related effects, such as the separation risk and the productivity differential, cancel each other out. The regional mobility of job applicants can mitigate or amplify age effects on the local labor market.

We expect that aging in the surrounding area affects the local BC to a lesser extent because it affects merely a part of the local exit probability. The local age proportion of younger workers changes the local BC of equation

(2) in case of differences in age-related separation risks, thus we have for the local area:

$$
\left.\frac{\partial u^l}{\partial p^l}\right|_{\partial\theta=0} = \left(u_y^l - u_o^l\right) - \left[\begin{array}{c} p^l u_y^l \frac{\theta^n \frac{\partial q^n}{\partial p^l}}{s+\tau_y+\theta^l q^l(\cdot)+\theta^n q^n(\cdot)} \\ + \left(1-p^l\right) u_o^l \frac{\theta^n \frac{\partial q^n}{\partial p^l}}{s+\tau_o+\theta^l q^l(\cdot)+\theta^n q^n(\cdot)} \end{array} \right]. \quad (16)
$$

We assume that $\partial q^n/\partial p^l > 0$, because aging affects regional mobility negatively. From this, it follows that the second term is always positive. Hence, $\partial u^l/\partial p^l < 0$ if $u_y^l < u_o^l$.[10] The overall effect is ambiguous if $u_y^l > u_o^l$. That is, a decline in the share of older people reduces equilibrium unemployment if, for example, older people have a higher age-specific separation rate. Relative to aging, this means that an increase in the share of older people increases the average flow in the labor market. It follows from the matching technology that given a constant rate of job creation, higher total separation risk corresponds to higher equilibrium unemployment.
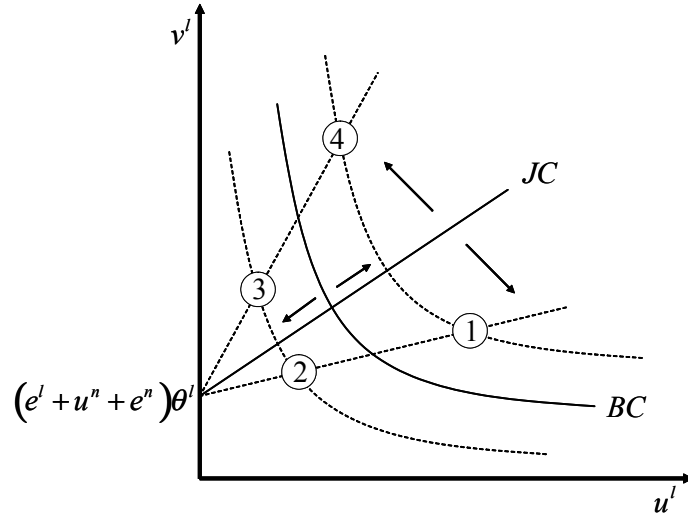

Figure 1: The effects of aging on the local search equilibrium

Figure 1 shows equilibrium in the vacancy-unemployment space and illustrates the effects that can arise if the age structure influences flows in the labor market and job creation. The steady state condition for unemployment is the BC, which is convex to the origin by the properties of the matching technology. As usual, the BC is downward sloping. Unemployment is low if the vacancy rate is high because job seekers find new employment easily. The JC is the curve that maps the job creation condition. It has a positive

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[10] According to the data used in the empirical section we have, on average, $u_y^l - u_o^l = -0.7\%$.

intercept $((e^l + u^n + e^n)\theta^l)$ and shifts when the number of employed job seekers or the number of unemployed in the surrounding area changes. Firms prefer a large pool of job seekers because it is easy for them to find appropriate candidates for their vacancies and thus save search costs. Hence, firms create more jobs if local unemployment is high (for a given intercept of the JC) and the JC slopes upwards.

Taking the central equilibrium as a starting point, four different outcomes may occur if the ratio of younger to older workers decreases.[11] The results are henceforth denoted as regime (1) to (4). In regime (1), older workers increase the mean separation risk and due to an unfavorable productivity-wage ratio, they are less preferred by the firms. A growing share of older workers then implies that the BC shifts outwards and the JC rotates clockwise. The result is that unemployment increases clearly, but the effect on the vacancy rate is ambiguous. Regime (2) implies that firms still prefer younger workers, the number of which becomes fewer. However, older workers reduce labor turnover and the BC consequently shifts inwards. From this, it follows that fewer vacant jobs are available, but it is not clear whether this leads to higher unemployment as fewer job-worker matches are terminated and fewer people look for reemployment.

Unemployment decreases if the reduced labor turnover is combined with a favorable productivity-wage ratio of older workers. This takes place in regime (3). Finally, firms can intensify job creation because older employees are superior workers, but it is not clear whether this reduces unemployment if older workers have a high separation risk. The resulting increase in labor turnover is accompanied by more vacancies, but the total employment effect in regime (4) is ambiguous.

We now turn to the effects of regional interactions. Spatial interactions of regional labor markets can cause the regimes on a local labor market as well. The JC rotates clockwise if the number of mobile job searchers in the surrounding areas decreases, because this increases search costs for firms and this, in turn, decreases the number of vacancies as well as market tightness.[12] With respect to unemployment, the effect is ambiguous because the reemployment probability of the local unemployed people could increase and this shifts the BC inwards. However, according to Pissarides (2000), the overall effect on unemployment is expected to be positive because the market tightness effect dominates the BC effect.

For the sake of simplicity, we assumed in the model that only productivity differential, age-related separation risks, and mobility distinguish younger from older workers. However, no general effect is lost by this simplification. This is because other age-related heterogeneity also affects equi-

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[11] We analyze the case of a decrease in p because this occurs in the last years and will take place in the coming years.

[12] In addition, the intercept also decreases in this case.

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librium, either through changes in labor turnover or through changes in the value of a job-worker match. For example, one could think of age-related search intensities which affect reemployment probabilities and age-specific unemployment rates. Other examples would be firm-specific human capital or seniority, which could give older workers higher bargaining power or differences in the discount rates if younger workers value career progression in a job higher than the current salary. Moreover, one could argue that δ is a discrimination factor, which is positive if firms discriminate against older workers. In the case that employers prefer younger workers, because of prejudices or bad experiences with older employees, they may add an extra value to the observable productivity of the young.

The consequences of these examples would be a differential between J_o and J_y, which results in more or less job creation if the age structure changes. Hence, more age-related heterogeneity could be captured, but the considered effects represent the general impact of the age-structure, and the distinction between the four regimes remains untouched by different extensions of the model.

3   Empirical Analysis

As shown in the previous section, age-related changes in job destruction and job creation consider dynamics ignored by, for example, the simple shift-share approach, which uses the general fact that young workers have higher unemployment rates than old workers. In this section, we therefore investigate empirically whether aging of the labor force affects regional unemployment in Germany according to the results of the theoretical model, using dynamic econometric specifications. Moreover, we analyze whether spatial interactions of regional labor markets, particularly the age structure, can explain regional unemployment rates.

In order to capture changes in age-composition, we divide the labor force (analogous to the theoretical model) into young, p, and old, $(1 - p)$. We use a broader definition of young and old workers than most other studies, because we believe that many individual characteristics relevant for job creation and job destruction, such as quit rates and productivity changes, alter when workers are of middle age.[13] Hence, we label workers as young when they are between 15 and 39 years old, and old when their age is between 40 and 64 years.

To account for the age structure of the job seekers (which is unknown), we use the age distribution of the labor force. That is, we assume that the share of younger job seekers is equal to the share of the younger ones in the

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[13] For example, Börsch-Supan (2003) shows that the typical age-productivity profile peaks mostly when workers are in their 40s. The Federal Institute for Employment Research in Germany comes to the same conclusion.

labor force. This is because we have no information about the age structure of the on-the-job searchers.[14] As mentioned in the introduction, the ratio of young to old workers (15 to 39 years old to those between 40 and 64 years old) ranged between 1.5 and 0.6 at the regional level in Germany in 2000 and 2001. Figure 2 shows the ratio of the age groups (left scale) in relation to the unemployment rates at the regional level for 343 districts and monthly data for 2000 and 2001.
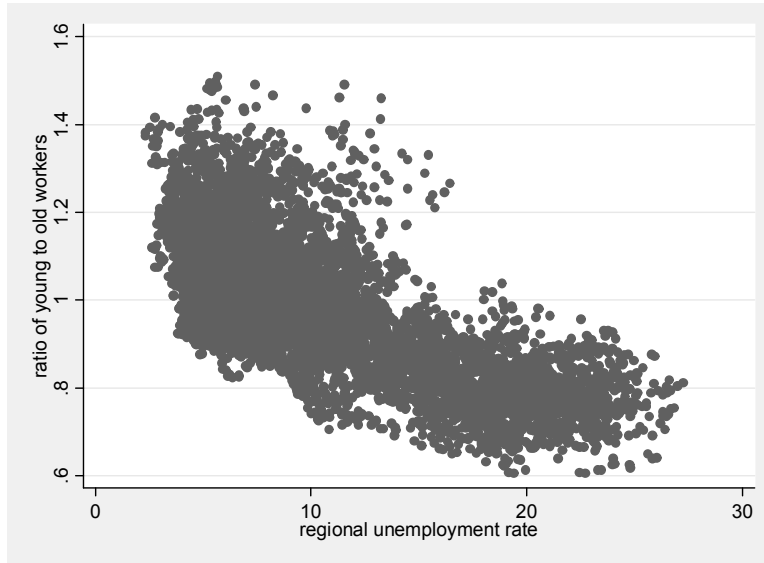

Figure 2: Unemployment and aging in Germany at the regional level

According to the data, aging approximated by the ratio of young to old workers is associated with higher unemployment at the regional level ($r = -0.71$). Moreover, the statistical relationship seems to be convex. According to Hetze and Ochsen (2006), who analyze aggregated time series data for Germany, periods of quasi-full employment have high and non-systematic variations in the age composition of the unemployed, but in times of high unemployment rates, even business cycle effects do not alter significantly the distribution of unemployment by age. The data depicted in figure 2 seem to be in line with this finding, although they represent primarily cross-section units and refer to the labor force. Hence, time series and cross-sectional data for Germany are related to a stable statistical relation between regional

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[14]However, it should be mentioned that this share can be underestimated. On the one hand, younger workers exhibit higher unemployment rates but older workers have larger birth cohorts. Hence, it is not known if the unemployed are, on average, younger or older than the labor force. On the other hand, on-the-job search decreases with age, and we can expect that the share of younger on-the-job searchers is above the average share in the labor force.
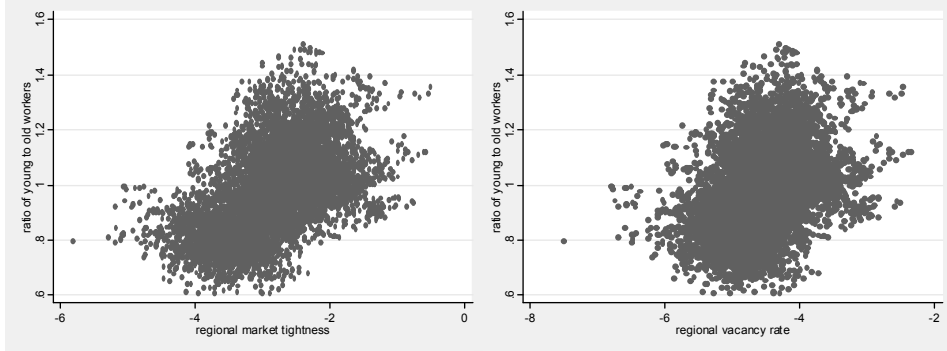
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Figure 3: Market tightness, vacancies, and aging

unemployment rates and the ratio of young to old workers.

With respect to the causal relationship, both directions are possible. In the supply side effect, young people move into regions with comparatively low unemployment rates, which in turn, foster aging in regions with high unemployment rates. In the demand side effect, firms could prefer younger workers, and in regions with a larger share of older workers, not only is job destruction higher, but the unemployment rate is higher as well. One drawback of the supply side effect is that it balances regional unemployment rates to a certain extent. In addition, this effect becomes unimportant at the aggregate level, given international net migration of the young is negligible. Hetze and Ochsen (2006) use macro data to analyze the demand effects of aging on unemployment and find a strong significant positive effect. To isolate the demand side effect in our data, we use an instrumental variable estimator.

We have shown in the theoretical section that the vacancy-matching ratio $1/q^l$ can be interpreted as an indicator of job creation. Firms open more vacancies for a given number of job seekers if $1/q^l$ increases. Since q^l depends on market tightness, we use θ^l as a proxy for job creation, because q^l is unknown. The vacancy rate is not an appropriate proxy for job creation, since job creation is conditional on job seekers. Firms respond to the unemployment rate and labor turnover with a certain quantity of new jobs. The statistical relationship between the ratio of the age groups (left scale) and the log of market tightness is depicted in the left-hand side of figure 3. According to the data, aging and market tightness are positively related ($r = 0.49$). This effect is driven not only by the unemployment rate as the right-hand side scatter diagram of figure 3 shows. Here, the relationship between the ratio of the age groups and the log of vacancy rate is also positive ($r = 0.33$). Moreover, the figures reveal a very similar pattern.

Figures 2 and 3 provide empirical evidence that aging can in fact affect

employment. At this stage, however, the figures are not more than an interesting observation, since the dependent variables are not conditional on wages, skills, etc. However, with respect to the four regimes in the theoretical section of this paper, our regional data for Germany do not seem not to allow the same conclusion as the macro data for Germany used in Hetze and Ochsen (2006). They conclude for the German labor market that job destruction increases with aging, and job creation also increases with the share of older workers. This combination of opposing effects yields regime (4). According to our data, however, job creation seems to decrease with aging. With respect to the theoretical model in section 2, this means that the German labor market falls into the category of regime (1). In this case, the overall effects of aging on unemployment are unambiguously positive. In Hetze and Ochsen (2006), only the net effect was positive. However, a reliable answer can only be given based on appropriate estimates.

Figure 4 about here

To illustrate the distribution of unemployment and age at the regional level in Germany, we use the monthly data for September 2001 to map the 343 regions. Figure 4 shows the regional unemployment rates using dark blue for regions with high unemployment and light blue for regions with low unemployment. Unemployment is high in Eastern Germany and comparatively low in Southern Germany. In addition, we see, on average, that if the local region exhibits a high unemployment rate, then this applies to the neighbor regions as well. Hence, the age-related regional mobility effect from the surrounding areas may explain the difference between identified regimes (1) and (4), because a macro data approach would mix the two effects.

Figure 5 shows the ratio of young to old workers in the labor force for September 2001 in the 343 regions. In the dark blue regions, the ratio of young to old workers is high, while it is low in the light blue areas. Compared with the unemployment rates, we see for the age group ratio almost a reversed pattern in terms of color. On average, the labor force is conspicuously older in Eastern Germany. In contrast to the unemployment rate pattern, the south does not differ from Midwestern Germany. Summarized, both maps suggest a strong statistical relationship between aging of the labor force and the level of unemployment at the regional level in Germany.

Figure 5 about here

3.1   Data

The period considered in this paper covers the years 2000 and 2001, and the data are disaggregated to 343 regions (266 in Western Germany and 76 in Eastern Germany) with a monthly frequency. The decision for this short time span may be explained by different reasons. First, vacancies were

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available at this disaggregation level since January 1998. Second, in 1998 and 1999, some regional borders changed, and the economic indicators are not comparable before and after this change. Third, in January 2003, the labor market reforms (so-called Hartz Reformen) took effect, which makes a comparison before and after the reforms difficult. In addition, the reform process has 4 stages and has taken 3 years. Fourth, in the years considered, the regional GDP growth rates are positive, while in 2002 and 2003, most regions experienced a recession. Finally, in 2000, the European Union started an investment program that particularly affected regions in Eastern German.

An important advantage over the international and time series based study by Hetze and Ochsen (2006) is that labor market institutions cannot account for regional differences because they are set at the macro level and remained unchanged in 2000 and 2001. In addition, business cycles are negligible because the economic conditions are fairly stable in these two years. This is important because at the beginning of a recession, it is often observed that younger people are more often laid off than are older workers. Furthermore, the vacancy rate is sensitive to fluctuations in the business cycle.[15]

Our proxy for p is the share of employed plus unemployed between 15 and 39 years old. In principle, this variable should capture the differences in the value of a match with a younger or older worker that stems from a change in age composition. The first instance refers to τ_y, τ_o and δ; however, if trade unions have different bargaining strategies relative to the age groups or the discount rate is different for the two age groups, this will be captured by p as well. Furthermore, income during unemployment can have components in addition to unemployment benefits that may be different for younger and older job seekers. This means that p controls for unobserved heterogeneity in the econometric model, which comes from a changed proportion of young workers.

To identify the effect of the distribution of the labor force by age on job creation and job destruction, we estimate the core equations in section 2, the BC and the JC. While the BC is estimated several times in the literature, the JC is exceedingly difficult to identify. Our approach to generalize job creation is given in equation (14), which indicates that the vacancy-matching ratio, $q^l\left(\theta^l, p^n\right)$, is an indicator of job creation. An increase in this ratio means that firms open more vacancies if the number of job seekers increases. Hence, we chose θ^l as a proxy for job creation. The age distribution in the neighbor district will be considered on the right-hand side of the equation.

The data used are taken from the Federal Statistical Office and the Federal Institute for Employment Research in Germany. The number of

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[15] See, for example, Davis et al. (1996) for a detailed discussion of the cyclical behavior of job creation and destruction.

employed (E) and unemployed (U) are taken from the Federal Statistical Office, while the data for the vacancies (V) are taken from the Federal Institute for Employment Research. These data are used to calculate the unemployment rate ($U/(E + U)$) and vacancy rate ($V/(E + U)$). Both rates have the same denominator, which is necessary for an appropriate representation of the BC. The share of on-the-job searchers (e) is unknown at the regional level. According to the Federal Statistical Office, the on-the-job seeker rate is about 10% at the macro level. We use this rough number to calculate the number of on-the-job seekers at the regional level. From this, it follows that market tightness is not accurately approximated, and this must be considered when we interpret the results. A second reason for this inaccuracy is related to underreporting of vacancies to the agencies of the Federal Employment Office.

We merge these data with variables taken from the IAB employment sample (IABS). This panel contains information on the course of employment and unemployment, and the individual sociodemographic characteristics of more than 1 million individuals. We aggregate the individual information to the regional level of 343 districts. The sociodemographic characteristics of the individuals, which serve as control variables, address information about age, education, employment status, wages, and employment classification according to the economic sectors. Education is subdivided into three groups: low educated (those who have no vocational education), medium educated (those who have a vocational education), and high educated (those who have an academic degree). In the estimates, we use the low educated as a reference group. Wages are considered as relative age wages and relative education wages. The former is calculated as the average daily income of people 40 years and older divided by the average daily income of those who are less than 40 years old. The latter is calculated as the ratio of the average daily income of low educated to high educated workers. In both cases, we consider only those who were employed full time. The number of employed is subdivided into three groups: full-time employed, part-time employed, and petty job worker. All three groups are considered as shares. In addition, we subdivide the full-time employed into two groups based on wages. The share of low wage earners is determined by those who earn less than 100 € a day, and the rest of the full-time employed where pooled into high wage earner. Finally, to control for differences in regional economic activities, we consider eight different sectors, weighted by employment shares.[16]

Our main interest lies in the effect of aging and in the spatial interaction of local labor markets. Hence, we will focus on these data in the empirical section. The control variables comprise on-the-job search and the

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[16]A: Energy, agriculture, and mining; B: raw/basic materials and goods; C: manufacturing-industrial goods; D: manufacturing-consumption goods; E: construction; F: trade; G: transport and communication; H: services.

data generated based on the sociodemographic variables in the local and the neighbor region. In order to generate spatially lagged counterparts, we construct a spatial weight matrix indicating the contiguity of regions. We define contiguity between two regions as regions sharing a common border. The corresponding spatial weight matrix W is therefore a symmetric 343×343 matrix. W is row normalized, which ensures that all weights are between 0 and 1, and weighting operations can be interpreted as an average of the neighboring values. For example, WU_t gives the average number of unemployed in the regions that share the border with the local region.

3.2 Econometric Models

In order to estimate precisely the effects of interest and given the limited data availability, the econometric models should be as compatible as possible with the theoretical model. The theoretical model does not consider explicitly unemployed people and vacant jobs, respectively, which exist for more than one period. Therefore, we account for the path dependence of both the unemployment rate and market tightness. In contrast to the standard hysteresis model of unemployment, we also consider the spatial lagged and space-time lagged unemployment rates. For the JC, we include market tightness in the same way.

That is, in addition to the simple time lagged dependent variable, we calculate the spatial lagged and space-time lagged dependent variables as follows: $W\tilde{u}_t$, with $\tilde{u}_t = log\,(u_t)$, is the spatial unemployment rate (in logarithm) in time t, $W\tilde{u}_{t-1}$ is the spatial unemployment rate (in logarithm) in time $t-1$. With respect to market tightness, we use the same procedure. We use these spatial lagged and space-time lagged variables as explanatory variables: $\log\,(u_{jt})$, $\log\,(u_{jt-1})$, $\log\,(\theta_{jt})$, and $\log\,(\theta_{jt-1})$.

To account for additional spatial interactions, we additionally calculate for some control variables X_t the average neighborhood value WX_t. That is, we consider the age, skill, and wage composition in the surrounding areas as well. With respect to the BC, we follow the modeling in the theoretical part and control for vacant jobs in the local and neighbor regions. Hence, the vacancy rates will be treated in the same way as the X variables, and enter eq. (18) as $\log\,(v_{it})$ and $\log\,(v_{jt})$, while the latter is calculated using the spatial weight matrix.

The considered econometric methods can be subdivided into two classes. The first class of estimation techniques consists of standard methods that account for the dynamic effects of the unemployment rate and market tightness in a naive manner. The first model is a simple pool estimator (Pool) that accounts for time effects, while the second one is a standard fixed effects model (FE) that also accounts for time effects. In contrast to the second model, the third uses Driscoll and Kraay standard errors (FE(DC)). Driscoll and Kraay (1998) argue that spatial correlations among cross-sections may

arise for a number of reasons, ranging from observed common shocks, such as terms of trade or oil shocks, to unobserved contagion or neighborhood effects.[17] Building on the non-parametric heteroskedasticity and autocorrelation consistent covariance matrix estimation technique, they show how this approach can be extended to a panel setting with cross-sectional dependence.

Although we are principally interested in age effects, we consider an alternative approach, because the spatial and time dynamic effects of the dependent variable are biased in the considered methods.[18] Hence, in the second class of estimation techniques, we use a spatial and time dynamic data approach with both regional and time fixed effects as suggested by Lee and Yu (2007) and Yu et al. (2008). In this case, the parameters for the time lagged, spatial lagged, and space-time lagged values of the dependent variables will be estimated using a quasi-maximum likelihood estimator that is extended by a bias correction. To avoid biased estimates for the lagged effects of the dependent variables, Lee and Yu (2007) developed a data transformation approach that has the same asymptotic efficiency as the quasi-maximum likelihood estimator when n is not relatively smaller than T.[19] Hence, the fourth model is an unbiased spatial and time dynamic panel data model with both regional and time fixed effects (STDFE).

The models have the following general specification:

$$Y_{nt} = \gamma_0 Y_{n,t-1} + \lambda_0 W_n Y_{nt} + \pi_0 W_n Y_{n,t-1} + X_{nt}\beta_0 + c_{n0} + \alpha_{t0}l_n + V_{nt} \quad (17)$$

where $Y_{nt} = (y_{1t}, y_{2t}, \ldots, y_{nt})'$ and $V_{nt} = (v_{1t}, v_{2t}, \ldots, vnt)'$ are $n \times 1$ column vectors and v_{it} is i.i.d. across i and t with zero mean and variance σ_0^2. W_n is an $n \times n$ spatial weights matrix which is nonstochastic and generates the spatial dependence between cross sectional units y_{it}, X_{nt} is an $n \times k_x$ matrix of nonstochastic regressors, c_{n0} is $n \times 1$ column vector of individual fixed effects, α_{t0} is a scalar of time effect and l_n is $n \times 1$ column vector of ones. W_n is row normalized from a symmetric matrix, which ensures that all weights are between 0 and 1, and weighting operations can be interpreted as an average of the neighboring values.

This general specification will be applied to both the BC and the JC as discussed above. To make the effects of interest more visible, we provide the

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[17] According to Driscoll and Kraay (1998), the presence of such spatial correlations in residuals complicates standard inference procedures that combine time-series and cross-sectional data since these techniques typically require the assumption that the cross-sectional units are independent. When this assumption is violated, estimates of standard errors are inconsistent, and hence are not useful for inference.

[18] See, for example, Nickell (1981) with respect to the asymptotic bias of OLS estimation using the time lagged effect and, for example, Kelejian and Prucha (1998) for biased OLS estimates when spatial lagged effects are considered.

[19] With respect to our data, for which we have T relatively smaller than n, Lee and Yu (2007) show that the estimator is consistent with rate T and has a degenerate limit distribution.

two equations in an alternative notation:

$$\log\left(u_{it}\right) = \beta_0 + \beta_1 \log\left(u_{it-1}\right) + \beta_2 \log\left(u_{jt}\right) + \beta_3 \log\left(u_{jt-1}\right) \quad (18)$$
$$+\beta_4 \log\left(v_{it}\right) + \beta_5 \log\left(v_{jt}\right) + \beta_6 \left(1 - p_{it}\right) + \beta_7 \left(1 - p_{jt}\right)$$
$$+\eta' X_{it} + \lambda' X_{jt} + \varphi_i + \psi_t + \epsilon_{1it}$$

$$\log\left(\theta_{it}\right) = \alpha_0 + \alpha_1 \log\left(\theta_{it-1}\right) + \alpha_2 \log\left(\theta_{jt}\right) + \alpha_3 \log\left(\theta_{jt-1}\right) \quad (19)$$
$$+\alpha_4 \left(1 - p_{it}\right) + \alpha_5 \left(1 - p_{jt}\right)$$
$$+\kappa' X_{it} + \omega' X_{jt} + \varphi_i + \psi_t + \epsilon_{2it}$$

In both equations, φ_i and ψ_t are regional and time fixed effects, and ϵ is an error term. The estimated effects of the age composition, $\beta_6, \beta_7, \alpha_4$, and α_5, reveal how unemployment changes due to shifts of and moves on the BC. Furthermore, they identify the regime according to figure 1. For the first specification (*Pool*) we assume that $\varphi_i = 0$.

According to the specifications used, we consider the effects of aging on local firm decisions. As mentioned above, however, particularly the young people in the labor force could gravitate to employment rates in other regions. Hence, it is possible that the aging parameters in the BC and the JC suffer from a simultaneous equation bias. On this account, we run additional regressions and instrument the share of older people in the labor force by the one period lagged share. We estimate both equations with an instrumental variable (IV) estimator using the pool and the fixed effects IV models. In a second step, we substitute the share of older people in the labor force by its time lagged value. This model specification will be estimated with all four considered econometric methods discussed in this section and will be referred to as pseudo IV approach.

For the 24 months and 343 regions considered, we have 8,232 observations. However, due to the inclusion of time lagged effects, we lose 1 month and therefore have 7,889 observations available for the estimates. For the IV and pseudo IV estimates we lose no further observations, because we use the lost first cross section observation as instrument for the first month in the estimates.

3.3 Results

This section is organized as follows: We first discus the panel estimates without instrumenting the aging variable. The main results are provided in tables 1 and 2. Afterwards, we discuss the results of the panel IV estimates that are presented in table 3, whereas we focus henceforth only on age effects. Finally, the age effects using the pseudo IV approach are provided in table 4.

Table 1 shows the results for the BC in which the log of the unemployment rate is the dependent variable. Although the theoretical model does

not consider explicitly a time lagged dependent variable, we can conclude that the path dependent effect is definitely positive. According to the theoretical model, the spatial lagged unemployment rate has a positive effect on the local unemployment rate. In fact, both time and spatial lagged unemployment rates have a positive effect in all specifications provided in table 1. However, with respect to the magnitude of the lagged effects, only the results for equation (4) are unbiased. The space-time lagged effect of the unemployment rate, however, has an unexpected significant negative sign. Our conclusion is that this variable is nearly perfectly correlated with the time and spatial lagged unemployment rates, and this, in turn, affects the sign of the parameter.[20] An indicator of this conclusion is the variance-inflation-factor for this variable, which is 325.

The local vacancy rate has the expected negative effect, which is in accordance with the theory. More precisely, the corresponding parameter is the slope of the local BC. The estimated parameter for the curvature of the BC, however, is very small. In contrast to the local effect, the spatial lagged vacancy rate has no significant effect. Both the small local effect and the insignificant spatial lagged effect can result from under-reporting of vacancies to the local agencies of the Federal Employment Office. Hence, the estimated parameters should be interpreted rather as an approximation. On this account, we should be careful in concluding that there is no spatial interaction regarding the job finding rate.

With respect to the interpretation of the on-the-job search effects, we must bear in mind that vacancies are kept constant. The effect of an increase in local on-the-job search on the local BC is negative. That is, according to this effect, the BC shifts inwards when on-the-job search increases. This is in line with the conclusions based on the standard on-the-job search model, whereupon unemployment unambiguously decreases with higher on-the-job search. An increase in on-the-job search due to lower search costs, for example, increases the number of matches for a given number of vacant jobs. Related to the standard Pissarides on-the-job search model, we can argue additionally that the reservation productivity decreases and this, in turn, reduces job destruction. In both cases, the BC shifts inwards. The spatial on-the-job search effect is positive and, hence, shifts the local BC outwards. On the one hand, it is possible that higher local on-the-job search is leading to higher labor turnover and this, in turn, yields, on average, better matches. An increase in on-the-job search in the surrounding area will not cause such an effect on the local labor market, and this may lead to an outward shift of the local BC. In this case, the crowding-out effect on the local unemployed prevail. Another argument is that, given that younger job seekers have higher regional mobility than do older job seekers, the overall

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[20]See, for example, Greene (2008) for a remark that high collinearity between the X variables can cause a change of sign.

supply of younger job searchers in the local labor market increases. Since the average unemployment period for younger people is shorter, this means that they find new jobs more easily. This is to the disadvantage of older workers resident in the local labor market; thus, the local BC shifts outwards because of the longer unemployment spell of older workers. Hence, employment shocks in the neighbor regions decrease the probability to find a new job for the local older unemployed.

The local older labor force is positively related to the unemployment rate, which means that job destruction is higher in regions with a larger share of older people in the labor force. However, the effect is statistically weak in the favored model (4). For the share of older workers in the surrounding labor market, we find a similar effect, which is significant only in the case when spatial correlation is considered in the calculation of the standard errors. The statistically less important spatial age effect can be explained by a combination of two effects. First, as mentioned in the beginning of the second part of this paper, about 50% of the employed are regional mobile. Hence, the age structure in the spatial areas is of importance, but to a lesser extent than the local age structure. Second, given that younger people are more mobile than older people, aging reduces the share of regional mobile workers which, in turn, decreases the spatial age effect on local unemployment.[21] Another reason for the insufficient significance level of this effect is that it affects the local BC merely through one of the two exit probabilities. Summing up, according to the age effects on job destruction in the theoretical section, regime (1) and regime (4) remain relevant.

Table 1 about here

With respect to the control variables for educational differences, we find no significant effects. That is to say, according to our data, job destruction at the regional level is not driven by the education mix of the labor force in Germany. The distribution of full-time, part-time, and petty job employed affects job destruction only with respect to the share of petty job workers. According to models (2) to (4) in table 1, there is a significant positive relationship between the share of petty jobs and job destruction. This effect is as expected, because these jobs have, on average, a higher job turnover rate, which in turn, shifts the BC outwards.

In table 2, we provide the results for JC. As in the BC estimates, the time lagged effect of the dependent variable is as expected and, hence, for JC, a path dependence exists as well. However, as mentioned for the previous table, the lagged effects of the dependent variable are estimated unbiased only in equation (4). With respect to the spatial lagged effect, we would argue according to the theoretical model as follows: An increase in on-the-job search in either of the two regions (local or spatial) decreases the search

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[21]See, again, footnote 6.

costs of the firms in both regions, if the job seekers apply for jobs in both regions. The search cost effect, in turn, increases market tightness in both regions.[22] Alternatively, one could argue that an increase of vacancies in the neighbor district for other reasons than on-the-job search decreases the unemployment rate in this labor market (as we have seen in table 1 the local labor markets have a stable BC). Because of the spatial interaction of the exit rates, this applies as well, to some extent, to the local unemployment rate. In turn, this increases the tightness of the local labor market. The spatial lagged effect in table 2 is in accordance with the theoretical explanations, while the space-time lagged effect has an opposing sign and is therefore not in accordance with the theory. However, the variance-inflation-factor for the space-time lagged variable is 48. Hence, it seems that the corresponding parameter suffers from a switch of the sign due to multicollinearity, as is the case in the BC estimates.

The spatial lagged wage ratio for old to young workers has a significant positive effect on local job creation. It does not seem plausible to assume that this effect reflects productivity differences between younger and older workers, because the corresponding local effect is not significant. Rather, it seems the relative lower the wages are for younger workers in the surrounding areas, the more often they apply for jobs in the local region. This wage-driven spatial mobility of younger workers has a positive effect on job creation in the local labor market. Another cautious conclusion is that productivity differences between younger and older workers seem to be small, on average. However, wages do not reflect age-related productivity differences correctly if earnings increase with age more than productivity grows.[23] With respect to the wage ratio of low educated to high educated, we find no significant effect.

The two aging effects are opposing on JC in the local labor market, except for the pool specification. The significance level, however, is somewhat ambiguous for both variables. If we consider the unbiased dynamic panel estimator (4) as the favored estimation, aging on the local labor market increases job creation (regime (4)), while aging in the neighbor districts decreases local job creation (regime (1)). The first result is in line with the findings of Hetze and Ochsen (2006) for Germany, according to which this is an indication of higher productivity among older workers. The second result means that the higher the number of younger job seekers in the neighbor district, the more jobs will be created in the local labor market.

This second spatial aging effect does not mean that the productivity differential between younger and older workers is reversed. A worker from the surrounding area, who is employed in the local region, will be considered

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[22] See, for example, Pissarides (2000) for a detailed discussion.

[23] For empirical evidence of differences between the age-earnings profile and the age-productivity profile, see for example, Lazear (1979) and Hutchens (1987, 1989).

in the local effect. Put differently, it is not possible that the spatial region will always have a higher productivity, because every region is a neighbor and a local district. That is, the spatial age effect cannot be interpreted as a productivity effect. Rather, the estimated effect reflects the spatial mobility of workers in the surrounding area. Since younger workers are more mobile, this seems plausible. The outcome of this effect is comparable to the standard on-the-job search effect on job creation. That is, the more people demand new jobs, the lower the search costs for firms; this, in turn, increases job creation.

However, if this is the case, then why does the local labor supply yield to an opposing effect? One explanation is that both younger and older job seekers in the local labor market apply for vacant jobs in this region. Hence, regional mobility no longer has any influence on job creation if aging is restricted to the local area. This means that if aging happens in the local and neighbor regions in a similar way, the overall number of job seekers is reduced, which in turn, increases search costs and reduces job creation in both regions due to the spatial interaction.

Table 2 about here

The supply of skills has a somewhat surprising effect on job creation. According to the results, an increase in the supply of medium educated people to the disadvantage of the low educated reduces job creation. In addition, the supply of high educated labor has no significant effect on job creation. These results contradict those of the literature on the causes of regional growth. However, the results are driven by East-West differences. We ran additional regressions (not shown here) with separated East and West effects, and found a significant positive relation between education and job creation for Western Germany. In addition, it seems that the classification of education groups is insufficient. The low educated are those who have no vocational education. In some regions, the share of the labor force with this education level is about 1%, and the mean is about 3.3% in Eastern Germany, and 15.6% in Western Germany. This reflects the differences in the education systems of the former West and East German countries. However, not only is the formal education higher on average in the eastern part of Germany, but so is the unemployment rate. Since education is only a control variable in the context of this paper, we will not focus more on this puzzle.

We now use the pool IV and fixed effects IV estimators to analyze how much the simultaneous equation bias affects the estimated effects of the aging variable. Table 3 provides estimates for both the BC and the JC. Regressions (1) and (2) are related to the BC, while regressions (3) and (4) are specifications of the JC. According to the estimates, the simultaneous equation bias has decreased the parameters of the age effects in the fixed effects

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estimation of the BC. With respect to the JC, we derive the same result for both estimates of the local effect, and the significant level has increased in both equations. The spatial effect increases somewhat in magnitude in the fixed effects IV estimation, and the effect is still significant at the 5% level. According to the results, the local effects are now both significant and positive. In addition, the spatial aging effect is significant for job creation. Hence, the demand side driven causality seems to be of importance.

Table 3 about here

To consider all models in table 1 and 2, we now use the time lagged share and the spatial time lagged share of the older labor force instead of the actual and the spatial lagged share. Put differently, we employ a more naive approach here, in which we impose the instruments directly, without estimating two stages.[24] Hence, the only difference between table 1 and the upper part of table 4 is that in the latter, the aging proxies are time lagged by one period. A comparison with the estimates in table 1 shows that, on average, the estimated parameters increase if we use the time lagged values. In addition, the significance level has increased in the favored model (4).

For job creation, we find the same results related to the local effect in estimates (2) to (4), if we compare table 4 with table 2. The local aging effect has increased in magnitude and is now significant at least at the 5% level in regressions (2) to (4). With respect to the spatial effect, the parameters in (2) to (4) have decreased, while the significance level has increased in (2) and (4). The results in table 4 are in accordance with the IV estimates provided in table 3, whereas the effects in the true panel IV estimates are somewhat stronger. Hence, the pseudo IV results are very similar to the usual IV estimates. With respect to the favored spatial and time dynamic panel data estimates (4) as suggested by Lee and Yu (2007), we now get significant parameters for the local as well as for the spatial aging effect on both job creation and job destruction, which are significant at the 1% level with one exception.

Table 4 about here

The age structure has effects on flows in the labor market and the expected value of a match between jobs and workers if the effects measured by the share of older people in the labor force are different from zero. We find that, in principle, the IV and pseudo IV estimates are similar to those of the usual estimates. Hence, the general conclusions with respect to the effects of aging do not change if we consider the IV estimates. In most cases, however, the significance level increases.

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[24]This does not yield efficient standard errors, but allows for a comparison of all methods used.

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According to the results, aging in the local and surrounding labor markets shifts the BC outwards. However, the effect of the latter is statistically weak. With respect to JC, we find opposing effects of aging. While the local effect is positive, the spatial effect is negative and larger in magnitude. With reference to the theoretical model in section 2, we therefore identify regime (4) if we consider only the local effects and regime (1) if we also consider the spatial effects of aging. In other words, if aging happens in the local and the neighbor districts, the unemployment rate will unambiguously increase in the local region. The results are not as so dramatically if aging happens only in the local region.

4   Conclusions

In this paper, at the regional level, we examined the relationship between the change in the age structure of the labor force according to demographic change and unemployment using both a theoretical and an empirical model. The modeling relates to search and matching in the labor market with on-the-job search. We extended the framework by spatial interactions and by age-specific effects on job creation and job destruction. From a theoretical perspective, the effect of an increasing share of older people in the labor force on total unemployment is ambiguous and divides into four possible regimes. Aging decreases unemployment if older workers bring more profits to the firms because of a higher productivity and a lower separation risk (regime 3). However, unemployment increases with a higher proportion of older job seekers if firms prefer younger workers due to productivity and separation differences (regime 1). Spatial interactions between neighborhood regions are implemented in such a way that it affects both job creation and job destruction in the local region. Hence, aging in the surrounding regions can exacerbate or mitigate the effects that emerge within a local region, because it affects the exit rate from local unemployment as well as the search costs of local firms.

In the empirical part, we examine the consequences of an aging labor force on equilibrium unemployment in the local labor markets using monthly data for 343 districts in German and the years 2000 and 2001. To discover the effects, we estimated two equations: The Beveridge curve and the job creation curve. We apply different estimation techniques, including a dynamic panel data estimator suggested by Lee and Yu (2007). According to the estimates, aging of the labor force indeed has effects on unemployment at the regional level. Based on our proxy for aging, which is the share of older people (40 to 64 years old) in the labor force, ongoing aging will cause an increase in local job destruction. In addition, aging in the local labor market increases job creation, while aging in the surrounding areas has a negative effect on job creation in the local district. Summing up, the results

imply that regional unemployment rates increase when the share of younger job seekers continuously decreases in the local and the surrounding areas. This applies particularly to the Eastern German regions, where aging of the labor force happens area-wide.

Regime (1) is less advantageous than the others because it implies that the demographic change is followed by a rise in unemployment. This poor result can arise because of misleading policy interventions but also because of individual behavior and preferences. Our interpretation with respect to the Beveridge curve is that aging increases the average separation risk. For job creation, we argue that firms respond positively to the local share of older workers because of productivity differences but negatively to the share of older people in the neighbor district because of increasing search costs.

The opposing local effects of aging on job creation and job destruction might be explained by the ambiguous outcome of early retirement schemes.[25] On the one hand, there is more labor reallocation and job destruction. On the other hand, firms have the possibility to dismiss unproductive old workers and to keep the highly productive ones. The early retired workers are removed from the group of job candidates. This raises the search productivity and firms are willing to create new jobs. But job creation benefits only artificially from aging, and the positive effect will disappear as soon as the early retirement programs phase-out. The surrounding area effect of aging on job creation differs from the local effect because younger workers are more mobile than are older workers. From this, it follows that regional mobility of older people in the labor market must increase.

As politics turns away from early retirement schemes and increases in the retirement age are implemented, future job destruction and job creation will depend critically on the wage-productivity ratio of old workers. But severe wage cuts for old workers would concern an increasing share of the aging labor force. Hence, further qualification and lifelong learning are of growing importance for employment levels and the quality of job-worker matching.

However, to avoid negative employment effects because of the demographic change, more research is needed to determine the specific causes. If firms favor young employees, one should expect that demographic aging means higher unemployment rates. The way policy should deal with this outcome, though, is not yet clear. Higher average education can explain the advantage enjoyed by young workers in the past. Alternatively, a poor productivity-wage ratio due to seniority wages or age discrimination as well as higher employment protection for older workers can also be the cause.[26] In the first case, the effect of aging will disappear because future

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[25] Alternatively, even if early retirement is not possible, the Beveridge curve shifts to the right if the rate of retirement from employment is higher than the rate of retirement from unemployment.

[26] Indeed, age discrimination seems to play some role in the dismissals and the (re)employment of old workers. Johnson and Neumark (1997) provide evidence for the

older workers; i.e., those presently in their middle age, are, on average, more educated than actual older workers. If seniority wages are the reason, then only changes in the wage profile can stimulate job creation in an aging labor force. Instead, a better information policy is necessary in case of age discrimination. Finally, if labor market institutions, such as employment protection, are the cause, it will be necessary to encourage more flexibility in employing older workers. However, this will be difficult for policymakers, because the share of older people (voters) is large and will increase steadily in the coming decades. Nevertheless, improvements in these fields could move the labor market towards the superior regimes and thus prepare it for demographic change.

Appendix

Wage Determination: Individual with attribute i can be younger $i = y$ or older $i = o$. Firms have information about the worker's age but wages follow from identical bargaining rules. Workers receive $W_i - U_i$ from a new employment, whereas the firm gets J_i. According to Nash bargaining the wage satisfies:

$$w_i = \arg\max \left(W_i - U_i\right)^{\beta} J_i^{1-\beta}. \tag{20}$$

The first order condition is

$$0 = \beta \left(W_i - U_i\right)^{\beta-1} J_i^{1-\beta} \frac{\partial W_i}{\partial w_i} + (1-\beta) J^{-\beta} \left(W_i - U_i\right)^{-\beta} \frac{\partial J_i}{\partial w_i}. \tag{21}$$

Solving eq. (8) for W_i and differentiation with respect to wages gives:

$$\frac{\partial W_i}{\partial w_i} = -\frac{\partial J_i}{\partial w_i} = \frac{1}{r + s + \tau_i}. \tag{22}$$

We use the equation in eq. (21) and have:

$$\beta \frac{J_i}{r + s + \tau_i} = (1 - \beta) \frac{W_i - U_i}{r + s + \tau_i}. \tag{23}$$

From this we see that the extra value received by a worker is a factor $\beta/(1-\beta)$ of the value which remains in the firm:

$$W_i - U_i = \frac{\beta}{1 - \beta} J_i. \tag{24}$$

Using the equation in (8), and substituting J_i for (11) and (12), yields:

$$w_o = (1 - \beta) r U_o + \beta \mu, \tag{25}$$

USA, and Charness and Villeval (2007) find age discrimination in France.

$$w_y = (1 - \beta) \, rU_y + \beta \, (\mu + \delta). \tag{26}$$

Employed workers receive an income that lays between their reservation wage indicated by rU_i and the full surplus that an employment generates. Both boundary values can be different for older and younger workers.

From eq. (3) and eq. (4) we can see that firms evaluate an employment according to $J_o = (\mu - w_o) / (r + s + \tau_o)$ and $J_y = (\mu + \delta - w_y) / (r + s + \tau_y)$. This and (24) yields:

$$W_o - U_o = \frac{\beta}{1 - \beta} \frac{\mu - w_o}{r + s + \tau_o}, \tag{27}$$

$$W_y - U_y = \frac{\beta}{1 - \beta} \frac{\mu + \delta - w_y}{r + s + \tau_y}. \tag{28}$$

Finally, with (7) we have:

$$rU_o = b + \left[\theta^l q^l \left(\theta^l, p^n \right) + \theta^n q^n \left(\theta^n, p^l \right) \right] \frac{\beta}{1 - \beta} \frac{\mu - w_o}{r + s + \tau_o}, \tag{29}$$

$$rU_y = b + \left[\theta^l q^l \left(\theta^l, p^n \right) + \theta^n q^n \left(\theta^n, p^l \right) \right] \frac{\beta}{1 - \beta} \frac{\mu + \delta - w_y}{r + s + \tau_y}. \tag{30}$$

From plugging eq. (29) into eq. (25) and eq. (30) into eq. (26) we get the wage equation presented in the text:

$$w_o = \frac{(1 - \beta) \, b + \beta \mu \left[1 + \frac{\left[\theta^l q^l \left(\theta^l, p^n \right) + \theta^n q^n \left(\theta^n, p^l \right) \right]}{r + s + \tau_o} \right]}{1 + \beta \frac{\left[\theta^l q^l \left(\theta^l, p^n \right) + \theta^n q^n \left(\theta^n, p^l \right) \right]}{r + s + \tau_o}},$$

$$w_y = \frac{(1 - \beta) \, b + \beta \, (\mu + \delta) \left[1 + \frac{\left[\theta^l q^l \left(\theta^l, p^n \right) + \theta^n q^n \left(\theta^n, p^l \right) \right]}{r + s + \tau_y} \right]}{1 + \beta \frac{\left[\theta^l q^l \left(\theta^l, p^n \right) + \theta^n q^n \left(\theta^n, pl \right) \right]}{r + s + \tau_y}}.$$

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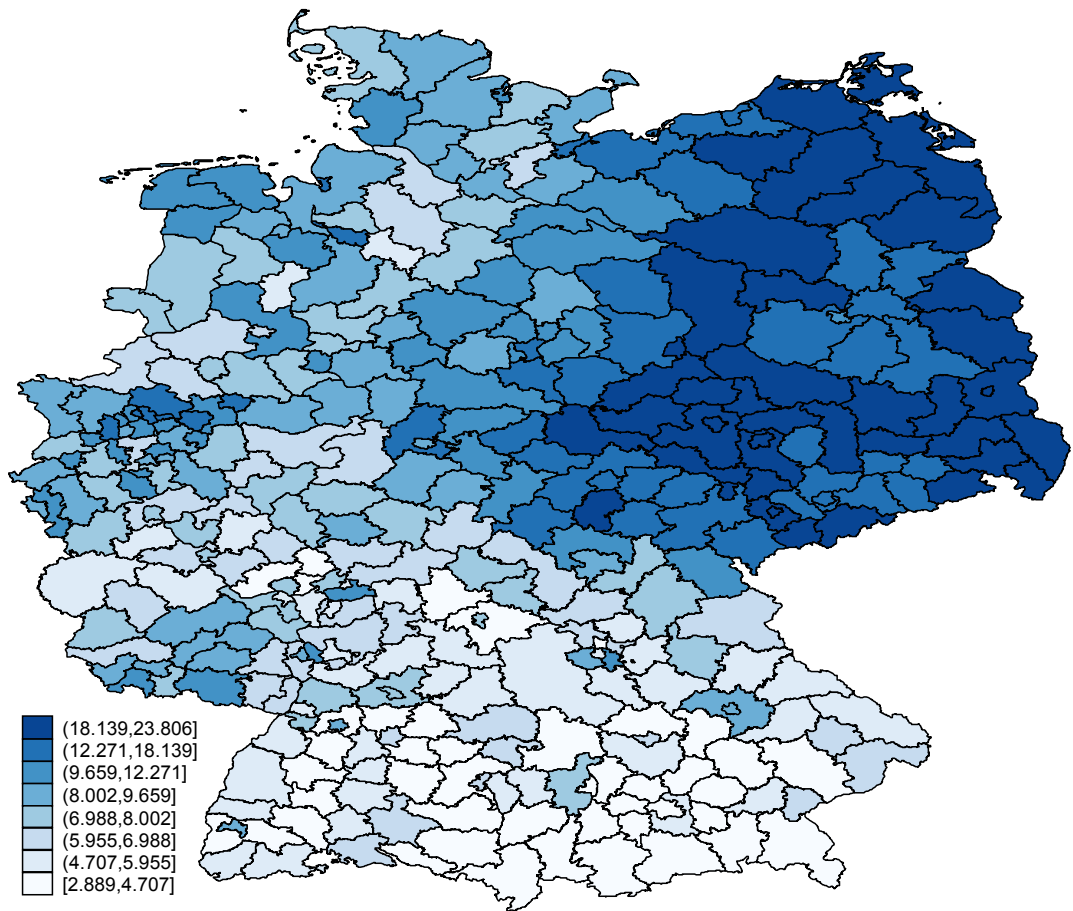
Figure 4: Regional unemployment rates in Germany (September 2001)

The legend from top (darkest) to bottom (lightest):

(18.139,23.806]
(12.271,18.139]
(9.659,12.271]
(8.002,9.659]
(6.988,8.002]
(5.955,6.988]
(4.707,5.955]
[2.889,4.707]
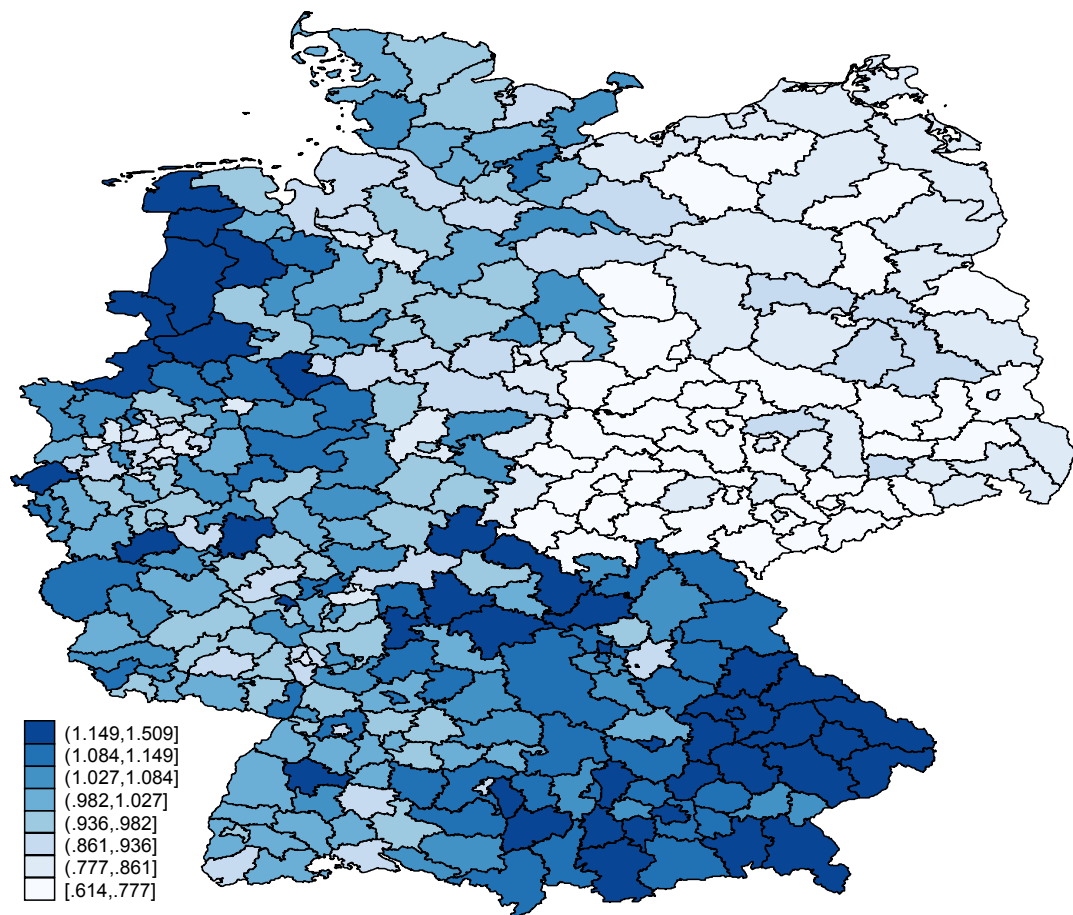
Figure 5: Ratio of young to old people in the labor force in Germany (September 2001)

(1.149,1.509]
(1.084,1.149]
(1.027,1.084]
(.982,1.027]
(.936,.982]
(.861,.936]
(.777,.861]
[.614,.777]

Table 1: Job Destruction

Variables	(1) Pool	(2) FE	(3) FE(DC)	(4) STDFE
time lagged dependent variable	$0.992^{\ddagger}$	$0.792^{\ddagger}$	$0.792^{\ddagger}$	$0.860^{\ddagger}$
spatial lagged dependent variable	$0.966^{\ddagger}$	$0.962^{\ddagger}$	$0.962^{\ddagger}$	$0.742^{\ddagger}$
spatial and time lagged dependent variable	$-0.966^{\ddagger}$	$-0.768^{\ddagger}$	$-0.768^{\ddagger}$	$-0.656^{\ddagger}$
vacancies	$-0.004^{\ddagger}$	$-0.009^{\ddagger}$	$-0.009^{\ddagger}$	$-0.012^{\ddagger}$
spatial lagged vacancies	$0.002^{\sharp}$	0.003	0.003	-0.002
on the job searcher	-0.001	$-0.237^{\ddagger}$	$-0.237^{\dagger}$	$-0.153^{\ddagger}$
spatial lagged on the job searcher	-0.001	$0.220^{\ddagger}$	$0.220^{\dagger}$	$0.139^{\ddagger}$
reference: younger labor force (15 to 39 years old)				
older labor force	$0.035^{\ddagger}$	$0.091^{\ddagger}$	$0.091^{\sharp}$	$0.073^{\sharp}$
spatial lagged older labor force	0.004	0.089	$0.089^{\dagger}$	0.124
reference: low educated				
medium educated	0.009	0.089	0.089	0.086
high educated	-0.010	0.093	0.093	0.053
spatial lagged medium educated	-0.004	-0.005	-0.005	0.002
spatial lagged high educated	-0.009	-0.006	-0.006	-0.019
reference: high income full-time employed				
low income full-time employed	$-0.015^{\dagger}$	-0.042	-0.042	-0.048
part-time employed	-0.005	-0.016	-0.016	-0.035
petty job employed	0.031	$0.101^{\ddagger}$	$0.101^{\ddagger}$	$0.094^{\ddagger}$
spatial lagged low income full-time employed	$0.026^{\ddagger}$	-0.021	-0.021	-0.060
spatial lagged part-time employed	-0.026	-0.105	-0.105	-0.099
spatial lagged petty job employed	0.013	-0.043	-0.043	0.001
regional fixed effects		✓	✓	✓
time fixed effects	✓	✓	✓	✓
regional sector shares	✓	✓	✓	✓
R^2	0.998	0.939	0.939	

NOTE: Number of observations: 7889; Pool: no regional fixed or random effects, with robust standard errors; FE: fixed effects with robust standard errors; FE(DC): fixed effects with Driscoll and Kraay standard errors; STDFE: spatial and time dynamic fixed effects; in equation (2) we have made the following tests: Breusch and Pagan LM test for random effects: $57.81^{\ddagger}$, Pesaran's test of cross section independence: $2.462^{\ddagger}$; $\ddagger = 1\%$ level, $\dagger = 5\%$ level, $\sharp = 10\%$ level.

Variables	(1) Pool	(2) FE	(3) FE(DC)	(4) STDFE
time lagged dependent variable	0.927‡	0.748‡	0.748‡	0.821‡
spatial lagged dependent variable	0.238‡	0.212‡	0.212‡	0.134‡
spatial and time lagged dependent variable	-0.202‡	-0.160‡	-0.160♯	-0.101‡
wage ratio old to young	-0.026	-0.005	-0.005	0.003
spatial lagged wage ratio old to young	0.007	0.192♯	0.192†	0.165†
wage ratio high to low educated	-0.043	-0.002	-0.002	0.004
spatial lagged wage ratio high to low educated	-0.011	-0.004	-0.004	0.001
reference: younger labor force (15 to 39 years old)				
older labor force	-0.158†	0.404	0.404	0.437♯
spatial lagged older labor force	-0.149	-1.020†	-1.020†	-0.997†
reference: low educated				
medium educated	-0.047	-0.777†	-0.777‡	-0.658♯
high educated	0.093	-0.837	-0.837	-0.320
spatial lagged medium educated	0.006	-0.036	-0.036	-0.019
spatial lagged high educated	-0.089	-0.040	-0.040	-0.052
regional fixed effects		✓	✓	✓
time fixed effects	✓	✓	✓	✓
regional sector shares	✓	✓	✓	✓
R^2	0.950	0.921	0.921	

NOTE: Number of observations: 7889; Pool: no regional fixed or random effects, with robust standard errors; FE: fixed effects with robust standard errors; FE(DC): fixed effects with Driscoll and Kraay standard errors; STDFE: spatial and time dynamic fixed effects; in equation (2) we have made the following tests: Breusch and Pagan LM test for random effects: 9.52‡, Pesaran's test of cross section independence: 18.43‡; ‡ = 1% level, † = 5% level, ♯ = 10% level.

Table 3: IV Estimates for Job Destruction and Job Creation

Variables	(1) BC PoolIV	(2) BC FEIV	(3) JC PoolIV	(4) JC FEIV
reference: younger labor force (15 to 39 years old)				
older labor force	$0.037^\ddagger$	$0.138^\ddagger$	$-0.147^\sharp$	$0.717^\ddagger$
spatial lagged older labor force	0.006	0.136	-0.149	$-1.355^\dagger$

NOTE: Number of observations: 7889; PoolIV: instrumental variable estimates without regional fixed or random effects; FEIV: instrumental variable estimates with fixed effects; $\ddagger = 1\%$ level, $\dagger = 5\%$ level, $\sharp = 10\%$ level.

Table 4: Time Lagged Aging Effects on JD and JC

Variables	(1) Pool	(2) FE	(3) FE(DC)	(4) STDFE
reference: younger labor force (15 to 39 years old)				
job destruction				
older labor force	$0.036^\ddagger$	$0.113^\ddagger$	$0.113^\dagger$	$0.120^\ddagger$
spatial lagged older labor force	0.006	0.111	$0.111^\dagger$	$0.143^\sharp$
job creation				
older labor force	$-0.144^\sharp$	$0.605^\dagger$	$0.605^\dagger$	$0.591^\ddagger$
spatial lagged older labor force	-0.146	$-1.199^\ddagger$	-1.199	$-1.138^\ddagger$

NOTE: Number of observations: 7889; Pool: no regional fixed or random effects, with robust standard errors; FE: fixed effects with robust standard errors; FE(DC): fixed effects with Driscoll and Kraay standard errors; STDFE: spatial and time dynamic fixed effects; $\ddagger = 1\%$ level, $\dagger = 5\%$ level, $\sharp = 10\%$ level.