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Larger pay, longer drives? Location specific wage effects on commuting distances

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Abstract

Over the past decades, commuting has become more and more important as a means for labor market adjustment. This is reflected in increasing commuter shares and distances. Nevertheless, identifying the determinants of commuting distances is by no means straightforward due to complex job and housing decisions. We argue that commuting results from a two-stage process where sorting leads to a temporary optimal housing/work combination that is adjusted in a second step. Due to differences in employment density, optimization results in diverse wage effects depending on the housing location. We focus on commuters who change their job and keep their place of residence. Using a mixed-effects design and matched data from the German ALWA-ADIAB survey, combined with precise wage information from administrative data, we are able to single out two aspects. Firstly, we identify the effects of wage level and wage change on commuting distance, and secondly, we analyze how these vary with the housing location. We find support for our assumptions that wage effects differ substantially as employees with higher wages generally commute longer distances but adjust their distance to a wage change predominantly in urban areas. Residents in rural areas keep their travel distances constant.

Introduction

Mismatches due to incomplete information or an increase in technology and specialization of tasks evoke a constant need for adaption on the labor market (Kalleberg 2008, Handel 2003, Jovanovic 1979, Autor 2013). Existing work arrangements may be dissolved if the combination of employees and employers is found to be non-optimal. As in such a case, adequate jobs may not always be found in the same area, a means for establishing new work arrangements is relocation or commuting. In recent decades, especially the latter has gained much attention due to rising commuter mobility in most industrialized countries. Indeed, focusing on Germany as the largest European economy, the importance of commuting has steadily risen (Kalter 1994, Hofmeister and Schneider 2010). The percentage of employees with different counties of residence and work increased from 31 percent in 1995 to 39 percent in 2005 (Haas and Hamann 2008). Moreover, commuting distances are increasing, growing from 14.6 km in 1999 to 16.6 km in 2009 (BBSR 2012).

Explanations can be found in substantial monetary and psychical relocation costs and a need to respond to rising imbalances on regional labor markets. Further, improved infrastructure and new technology including transportation means give people the option to accept job offers further from their place of residence, which is believed to facilitate the skill-matching needed for sustained economic development (Östh and Lindgren 2012).

A major interest lies in the amount to which commuting can provide labor adjustment, because the economy as a whole but individuals likewise can profit from better matches. In that context manifold studies have analyzed the effects of wages on commuting distances, because higher wages reflect an increased productivity and thus a better match. They usually agree in their findings that higher wages lead to longer commuting distances, thus supporting the notion of more productive employees commuting further (Groot, de Groot, and Veneri 2012, Abraham and Nisic 2007, Gutiérrez-i-Puigarnau and Van Ommeren 2013). However, they as well agree in a comparably small amount of the effect, which is surprising in the light of economics suggesting pecuniary means to be the main incentive for accepting longer commutes.

We argue that predictions and empirical findings lie apart, because a central element is missing in theoretical deliberations on wage effects on commuting distances. In our view, commuting is a consequence of a two-stage process, which results in diverse wage effects on commuting distances for different groups on the labor market. First, at labor market entry or after relocation an optimal housing and employer location combination is chosen. As predicted from urban economic theory, employees with higher wages will relocate further away from their workplace, as they have higher housing demands, which can usually be satisfied in less dense areas (Alonso 1964, Muth 1969). Second, however, due to incomplete but improving information on the labor market we assume an adaption process in which employees will chose a job with better matching and thus higher wages. Depending on the initially chosen housing location, higher wages may now result in longer commutes for some groups but not for others. Employees that located in less dense areas should have the probability to choose adequate vacancies from other regional labor markets without having to increase their commuting distance by much. Employees in dense areas, however, will either not commute at all or considerably increase their distance because they commute between urban areas, cities or the centers of regional labor markets. In this sense, the adjustment process only results in longer commutes for employees residing in urban centers, who are then mostly responsible for the positive wage effect. Accordingly, in agglomerations (Rhine-Ruhr, Rhine-Main, Stuttgart, Munich, Hamburg, Dresden and Berlin) 27% commute distances 5-10 km compared to 14% in rural areas. Larger distances (25 km and more) are more frequent in rural areas 21% (agglomerations 12%). All in all 4.4% commute more than 50 km (one way), 7.0% residing in core cities and 2.8% in rural areas (Wingerter 2014).

We thus combine theoretical urban models that assume that the residence location is endogenous (White 1988) with labor models which assume that it is given (Rouwendal 1999). Distinguishing between (1) sorting and adjustment processes and (2) regionally diverse effects on commuting distances then results in more precise predictions on the relationship between wages and commuting distance.

We use retrospective data from the survey ALWA-ADIAB to test if we find different wage effects for existing work-residence combinations and changes in commuting distances. We then analyze whether the latter effect indeed varies by the spatial location. We do so by applying a mixed-effects design, which distinguishes between and within-employee effects of wages and analyze the effects on commuting distance and the adjustment of travel distance due to a job change. The paper is structured as follows. First, we elaborate the theoretical background from which we derive hypotheses on the wage effect on commuting distances and changes in these. Second, we describe our analytical strategy, including the modelling design and the statistical method. Subsequently, we describe the data sets and our operationalization. Finally, we give an overview on descriptive and multivariate results before drawing a conclusion and giving an outlook on potential further research.

Theoretical background

Theories on the emergence and the change in commutes are manifold. From a labor market perspective workers should follow firms and therefore locate and relocate to where suitable jobs can be found. However, spatial limitations may prohibit the integration of places of work and residence at the same location. The basic urban economic theory argues that households choose their residential location to maximize their utility, balancing the increased costs of commuting against the advantages of cheaper unit price of land (Brueckner 2000, Muth 1969, Alonso 1964). In this framework households or individuals have to decide whether they want to profit from living in an agglomeration and thus having higher costs of living or whether they want to reside in a sparsely populated peripheral region with lower wages, but also lower costs of living. In spatial equilibrium all workers are thus fully compensated for longer commutes (travel costs) by lower housing costs. The commuting distance is solely based on the household preference.¹

However, several extensions to the model imply the emergence of commuting due to various reasons. Wasteful or excess commuting can originate through search imperfections and implies that workers commute between housing location A and work location B while other identical workers to the opposite (Hamilton and Röell 1982, Small and Song 1992, Manning 2003, White 1988, Merriman, Ohkawara, and Suzuki 1995, Horner and Murray 2002). Local amenities may further prolong

¹ A detailed discussion about the spatial equilibrium concept in urban economics can be found in (Glaeser and Gottlieb 2009, Puga 2010).

commuting distances (Ng 2008) and urban sprawl may lead to various directions of commutes (Travisia, Camagni, and Nijkamp 2010). A whole strand of literature on spatial mismatch argues that lower employment rates and longer commutes for some ethnic groups in the US result from the lack of appropriate local vacancies (Gobillon, Selod, and Zenou 2007, Kain 1968, 1992, Taylor and Ong 1995, Preston and McLafferty 1999, Holzer 1995) Moreover, some approaches imply that employees with higher wages commute longer distances. Greater housing demand for high-income households can lead to a sorting of employees with high wages into longer commuting distances (Brueckner 2000). Further, Manning (2003) argues that monopsony and thin labor markets lead to a positive correlation between wages and commuting distance. He argues that workers try to maximize wages and minimize commutes but job offers come at an infrequent rate, resulting in longer commuting distances for jobs with higher wages. Indeed, empirically, we can observe small positive wage effects on commuting distances (Gutiérrez-i-Puigarnau and Van Ommeren 2013, Manning 2003, Groot, de Groot, and Veneri 2012, Abraham and Nisic 2007, Zax 1991).

We argue, however, that the effect is somewhat underestimated, because a central piece is neglected in the above mentioned theories. The combination of standard urban economic theory and the idea of thin labor markets and market frictions lead to quite diverse predictions for the effect of wages on commuting distances. Including the spatial dimension of the former theory into the predictions derived from job-search models yields new insight the process of commuting on the labor market.

We claim that commuting results from a two-staged process in which employees *first* sort themselves into an optimal housing-work combination, as predicted from urban economic theory. However, we assume imperfect information and thus mismatches that can be dissolved when changing the employer (Jovanovic 1979). Accordingly, the idea of thin labor markets and search frictions suggests that appropriate job offers have a low arrival rate, potentially resulting in mismatches on the labor market. Thus, in a *second* step, employees can change their job to achieve a better match and thus higher wages. Due to substantial relocation costs, it is far more likely that employees will keep their housing location and adjust to the new labor market situation by commuting. Local specific capital (DaVanzo 1983) and rising costs in land rents and housing prices, especially as landlords may negotiate new rents when apartments become vacant (Basu and Emerson 2000), increase the costs of relocation vis-à-vis commuting. Moreover, given a preference for specific types of location, the choice of residence location may be optimal for a variety of respective workplace locations within acceptable commuting distances. As we assumed sorting into different housing locations, however, the adjustment will not necessarily result in increased commuting distances for all commuters. Given mono- or polycentric labor markets, employees who reside in rural areas with a lower employment density have a lower probability to find a high wage

job nearby. Even if jobs are taken on in a different economic center, new commuting distances will only vary to a low degree. Residents in urban areas or economic centers on the other hand will react more elastically. Either they change jobs locally or they have to increase the commuting distance by far, when they find jobs in other urban centers. Thus, depending on the initially chosen work-housing combination, we expect wage effects on commuting distances to vary considerably. A sorting effect should lead to a selection of high-wage employees into longer commuting distances. The adjustment process, however, should lead to positive wage effects mainly for residents in areas with high employment density.

We thus do not only suggest that wage effects on commuting distances have to be distinguished between sorting and adjustment. We moreover expect that the latter effect is driven by a specific group on the labor market. The change of commuting distance might be influenced by the spatial distribution of employment opportunities and will depend on the housing location.

Analytical strategy

Differentiating between sorting and adjustment

We assume different effects of wages on commuting distance and argue that first employees with higher wages sort themselves into housing-work combinations with longer commuting distances and that second adjustment processes lead to an increase in the commuting distance predominantly for urban residents. To separate the two effects, we regard job changes with a constant resident location. As shown in Figure 1 we allow for a maximum gap of six months between the two workplace spells and force the residential episode to be constant for at least three months before the end of the first episode and 12 months after the episode.²

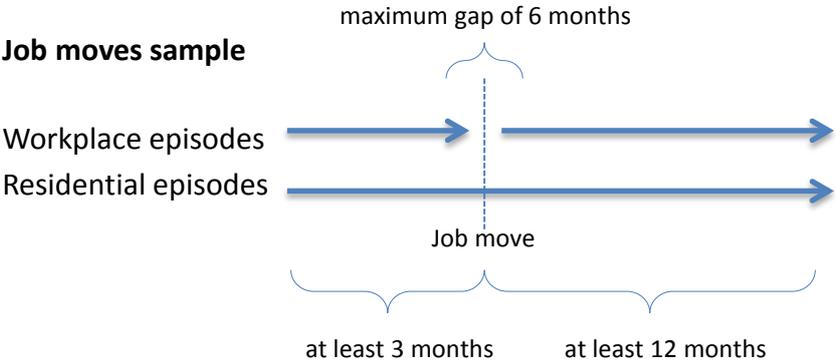


Figure 1 Sample selection

² For sensitivity analyses, we allowed the gap to vary between 0 and 6 months. The results did not change substantially.

We can thus first observe whether employees with longer commutes indeed have higher wages, and second analyze if employees accept longer commuting distances when changing to a job that grants higher wages. Keeping the residence location constant, we should obtain labor market driven changes in commuting instead of changes that rather result from responses to the housing market or from other reasons. Such changes—for example driven by housing demand—are important for commuting as well, however are not supposed to be directly linked to wages and are thus not of interest here. For all employees in the sample, we are then able to calculate the effect of income on the accepted commuting distance. A major advantage of exploiting the spell structure is that we are able to take changes in individual factors during the life-course into account. These may encompass events such as the birth of children or changes in civil status, which should influence commuting distances.

Further, we can address the problem of endogeneity in the relationship between wages and commuting distance. Trying to identify the causal effect of wages on commuting distance is not straightforward due to complex interactions (Haas and Osland 2014). Unobserved variables may cause spurious correlations. Higher productivity for example may positively influence both the wages and the travel distances. By keeping the place of residence constant, however, we can measure the mere effect of a change in the wage on a change in the commuting distance. This will most likely cancel out the effect of unobserved variables on both wages and commutes. Further endogeneity may arise from potential reverse causation (Gutiérrez-i-Puigarnau and Van Ommeren 2013). On the one hand, higher wages may provide the possibility of meeting preferences and thus of choosing a place of residence farther away from the employment location. On the other, employers may reimburse employees for commuting longer distances, thus leading to a reversed causal effect of commuting distance on wages.

There have been several approaches to tackle the problem of endogeneity. These mostly draw on an instrumental variable estimation. However, it is problematic to find adequate instrumental variables that do have an influence on wages but do not influence workplace location (Manning 2003). We argue that in case of an employment change, the potential wage will be known beforehand and reverse causation is not given in such a setting. Moreover, in Germany it is mostly uncommon that employers reimburse employees residing farther away as for the majority, the wage setting mechanism draws on wage posting instead of bargaining (Wallerstein, Golden, and Lange 1997, Brenzel, Gartner, and Schnabel 2013). Accordingly, Manning (2003) argues that in a competitive market, employers should pay the same wage to identical workers and that it is unlikely to be granted a pay rise because of a longer commuting distance. As a robustness check, however, we discard employees with the highest bargaining power, as this will most likely eliminate such those cases, in which increases in commuting distances can be ascribed to commuter-reimbursement. We

thus conduct our analyses both in- and excluding employment episodes that are connected to highly complex tasks and an executive position—defined as having at least one subordinated employee.

Statistical Method

The aim of this paper is twofold, as we first want to disentangle the sorting and the adjustment effects of wages on commuting and second want to analyze if the latter varies with housing location. To tackle these questions, we calculate the effect of the logarithm of wage on the logarithm of commuting distance using mixed-effect panel regressions.

Selecting the most recent job change in the individual career, we obtain a longitudinal data structure with constant places of residence. In this structure, panel measurements are nested within individuals and these are nested within regions, as shown in the classification diagram in Figure 2. Measurement occasions then may not be independent from unobserved individual and regional factors.

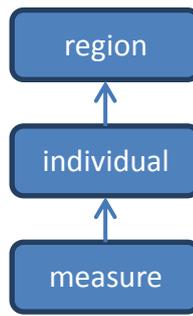


Figure 2 Classification diagram

Mixed-effects (also common under the term multilevel or hierarchical) panel regressions account for unobserved regional influences and allow for calculating the effects of residential location as well as density specific wage effects on commuting distances. A major advantage of the method is the possibility to estimate fixed and random effects, which are both of interest, as they analytically separate the sorting and adjustment process. Using group-mean centering, we obtain fixed effects for time-varying covariates and may further include time-invariant factors as well as an estimate for the unobserved variation between individuals and regions.

The model can be written as follows:

$$y_{irt} = \beta_0 + \beta_1(w_{irt} - \bar{w}_{ir}) + \beta_2\bar{w}_{ir} + \beta_3x_{irt} + v_r + u_{ir} + \epsilon_{irt}$$

with

$$v_r \sim N(0, \sigma_v^2), u_{ir} \sim N(0, \sigma_u^2), \epsilon_{irt} \sim N(0, \sigma_\epsilon^2)$$

where y_{irt} is a commuting measurement for month t for a given individual i in a given region r . $\beta_1(w_{irt} - \bar{w}_{ir}) + \beta_2\bar{w}_{ir} + \beta_3x_{irt}$ indicates the fixed part of the regression, while the random part consists of a random intercept v_r for regions and u_{ir} for individuals within regions and the individual residual ϵ_{irt} at measurement point t , conditioned on the individual and the region random effect. Separating the wage effect using Mundlak's formulation (Bell and Jones 2015, Mundlak 1978), we obtain a measure for the within effect of wage on commuting distance β_1 and a between effect of wage on commuting distance β_2 . The former represents the same effect we would obtain in a fixed-effects model while the latter represents the sorting or an endowment effect—namely the effect of wages on the former chosen commuting distance.

Dataset

In our analyses, we draw on retrospective data from the “ALWA survey data linked to administrative data of the IAB (ALWA-ADIAB)³, which is available through the Institute of Employment Research (IAB). It provides a dataset that links the retrospective survey “Working and Learning in a Changing World” (ALWA) (Antoni et al. 2010) to administrative data on the person and firm level (Antoni and Seth 2012, Antoni, Jacobebbinghaus, and Seth 2011). The survey was conducted in 2007/2008 and includes 10,177 computer assisted telephone interviews (CATI) that encompass monthly residential, work place, educational, employment and partnership histories in Germany (Kleinert et al. 2011). The sample is representative for Germany and covers people born between 1956 and 1988. The linked survey provides access to information of the Federal Employment Agency which allows us to consider accurate wage data for all employees in the data who are subject to social security contributions.

We additionally link distance measures between municipality centroids provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR). The measure is used to define commuters and commuting distance. Moreover, we include regional unemployment rates, the development in employment and employment density on the county level. The latter is used to differentiate between different wage effects depending on the housing location while unemployment rates and employment development are used to control for regional influences on wage effects.

Operationalization

Three constructs are at the heart of this analysis: Wage, commuting distance and employment density. The former is measured as the *logarithm of daily wage*, retrieved through

³ Access to the dataset is provided via the Research Data Center (FDZ) of German Federal Employment Agency at the IAB and is given through on-site-use and subsequent remote data access. See <http://fdz.iab.de/en.aspx> for more information.

administrative data of the BA for all employees that are subject to social insurance contributions. The wage data is linked to the ALWA survey on a monthly basis, achieving a high level of validity. We employ a method proposed by Reichelt (2015) to impute right-censored wages above the contributions limit, deflate wages and match the data to the survey structure. The *distance* is measured as the logarithm of the linear distance between municipality-centers of place of residence and place of work and is obtained through the BBSR. We calculate the employment density as the ratio of all employees subject to social security contributions in a given county to its spatial area in kilometer. Our empirical design demands a constant measure because the interaction of wages with a changing density would not be interpretable in a meaningful way. Therefore we obtain the measure for 2007 and assume it to be constant over the observational period.⁴

Our structural control variables are the county unemployment rate and the employment growth. We use further control variables for other determinants of commuting distance. *Formal education* is classified as the highest educational degree that has been obtained during regular schooling. The highest educational degree is controlled for by four dummy variables, encompassing (1) no degree (2) lower secondary [Hauptschule] (3) medium secondary [Mittlere Reife] and (4) upper secondary education [(Fach-)Abitur], which represents entrance qualification for university and tertiary institutions. As educational degrees may be obtained after regular schooling, we include a dummy variable indicating if a higher educational degree is obtained through *second chance schooling*.⁵ *Vocational and academic training* is controlled for by two dummies in reference to no vocational or academic training. As residential mobility costs can be affected by the composition of the household, we include variables for the family status. It is measured with dummies for living in a household without a partner, an unmarried partner and a married partner. Children in the household are differentiated between age groups and encompass years 0-3; 3-6 and 6+. Reduced hours are operationalized with a dummy, indicating contract hours lower than 30 hours a week at the beginning of contract time. We as well include a variable for the duration of residence in years to cope with local ties of employees without former relocation experience. To control for industrial sector-specific effects, an aggregation of the NACE classification is included with seven categories. Moreover, a dummy is included, indicating an employment relation within the public sector (vs. the private). Other controls cover yearly dummies, calendar dummies, age, sex and nationality. A complete list of control variables and descriptive statistics can be found in the appendix.

⁴ For robustness checks, we as well employed the employment density for 1995; however, the results did not change substantially.

⁵ We split the information on schooling in order to obtain separate effects for the degree of schooling before entrance into the labor market and second chance education.

Population under analysis

We restrict the population under analysis in the multivariate analysis according to several characteristics. The BA only collects income information for employees that are subject to social security contributions. Therefore we exclude self-employed and marginally employed. We draw on monthly information—both from retrospective survey data and process data—between January 1993 and the interview date in 2007/2008, as wage measurements for East Germany are missing before reunification. We use information on all primary employment relations, while a dummy variable is included for all secondary or overlapping primary employment relations. Moreover, observations before having obtained the highest regular schooling degree are excluded as we want to select regular employment relations. For the same reason, observations from employees below 18 years are excluded. We expel observations of employees with parallel places of residence as we are not able to identify commuting pathways for this population. Furthermore, observations with commuting distances above 200km are excluded, as we suppose other means (e.g. airplanes) or other types (weekend-commuters) of commuting. Nevertheless, we have no knowledge about how often per week a person commutes, whether it takes place on a daily or on a weekly basis.

To identify the effect of wages on commuting distance, we calculate sensitivity analyses with and without employees with highly specific skill requirements and a managerial position (at least 1 subordinated employee) as we suppose a higher amount of bargaining power. As we are using the logarithm of distance and wage, all observations are set to missing that have a commuting distance of 0km. Thus all observations, in which an individual resides in the same municipality where (s)he works are excluded.

According to our analytical design, we only keep information on those employees that have a constant place of residence and change the employer. For all employees that exhibit more than one job change with constant residence location, we select the most recent spell combination. We moreover exclude observations that correspond to more than a hundred percent wage increase, because we assume imprecise wage information.

Empirical Results

Descriptive evidence

The aim of this article is to evaluate whether sorting generally leads to a positive wage effect on commuting distances and whether adjustment leads to a positive effect of wage changes mostly for residents in areas with a high employment density.

After restricting our sample as above described, we obtain employment spells for 2,897 workers. These workers have at least one pair of working spells according to our definition and

exhibit 301,726 observations or months in employment. We observe positive commuting distances for 1,869 employees, tantamount to different work and residence locations for at least one employment spell. These episodes correspond to 151,816 monthly observations. We use this restricted sample for all further descriptions and multivariate analyses, because we use the logarithm of the distance in our regressions, which excludes distances of 0 km.

Table 1 shows the average wages and distance as well as the average changes in wages and distances. We use the mean wage for the employment episodes to indicate the amount of the change in wages. On average, we observe daily wages of round 90 Euros, which corresponds to a monthly gross wage of approximately 2,900 Euros. According to official statistics, the value is slightly higher compared to the population average. However, considering that we excluded non-commuters and assuming a positive relationship between commuting distance and wages this is not surprising. The average commuting distance lies at approximately 21 km, which shows that the majority of commutes are of short-distance nature. The average change in daily wages is positive with a 9.4 Euros increase, whereas the average change in distance is slightly negative with a quarter of a kilometer.

	Mean	Std.Dev	Min	Max
Daily Wage in EUR	95.29	65.10	12.03	978.77
Wage change in EUR	9.40	29.33	-202.35	161.01
Distance in km	20.97	19.97	1.42	188.91
Distance change in km	-0.25	18.54	-179.88	144.86

Table 1 Descriptive results for average wages and distances

To give an impression on the relationship between wages and distance, Figures 3 and 4 show scatterplots of mean wages and distances as well as average changes in wages and distances. The graphs show that wages and distances in general are positively correlated, but the relationship between wage and distance changes is fairly small. This corresponds to our expectation that we do observe a positive sorting effect and that the adjustment effect might be underestimated when ignoring the spatial structure. Descriptively, we only observe a very small positive effect of wage changes on distance changes.

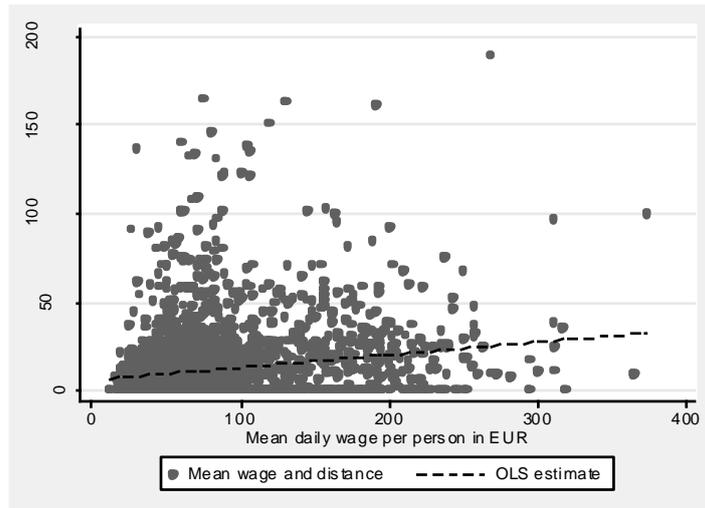


Figure 3 Scatterplot: Mean wages per person and commuting distances

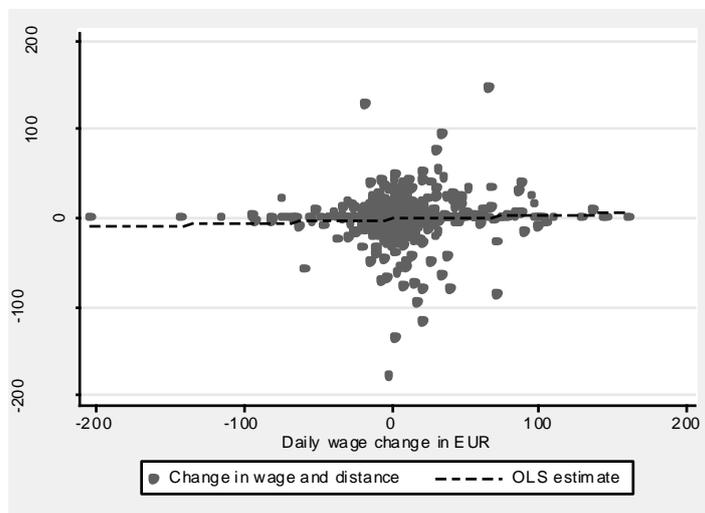


Figure 4 Scatterplot: Average change in wages and commuting distances

Multivariate evidence

The descriptive results mainly support our assumptions on rising commuting distances with wages due to sorting effects and a small positive effect of wages on distances. For a more detailed analysis and for testing the assumption that the latter effect varies with the employment density we employ multivariate analysis. We use mixed-effect panel regressions to analyze the effect of the logarithm of wage on the logarithm of commuting distance as well as regional differences in this effect. Table 2 shows a main, an interaction effects model and a model with regional control variables. It gives information on the influences on commutes for all employees that keep their place of residence constant and change the workplace at least once. For the purpose of readability, we only depicted a selection of all variables. Full models, with all control variables can be found in the

appendix. We keep the sample identical for all models and obtain 95,579 observations for 1,280 individuals in 244 counties.

The main effects model includes all controls on the individual level and focuses on the main effects of employment density, the logarithm of the groupmean-centered wage and the logarithm of the change in wages. The employment density seems to have no effect on the distance traveled to work. Thus sorting does not solely seem to depend on the housing market. While this effect may be counterintuitive at first, one has to keep in mind that we are only including positive commutes, because we include the logarithm of the commuting distance. Thus, all employees who reside and work in urban centers (intracity commuters) who show presumably low commuting distances are excluded.⁶ Moreover, as we observe the most recent job changes, the initial commuting distance might already be subject to an adjustment process of the initial residence-work combination.

The effect of groupmean wages on commuting distances supports our assumption that due to sorting, higher employees with higher wages choose housing-work combinations that lie farther apart. Urban economic theory would predict that greater housing demand for employees with higher wages lead to an increase in the distance between residence and work location. However, we cannot preclude that other factors did drive the sorting of employees with higher wages into longer commuting distances.

The effect of a change in the wage is significantly positive as well, indicating that employees—notwithstanding their residence location—accept a longer commute for an increase in daily wages. Employees with 10 percent higher wages commute about 1.4 percent longer distances⁷. This supports the assumption that incomplete information or structural factors promote a change in the job to improve matching and realize higher wages. However, in line with results from other studies, this effect is rather small (Gutiérrez-i-Puigarnau and Van Ommeren 2013). The estimate can be understood as the mean effect over all regions and persons and indicates that for instance a 10 percent increase in wages would only lead to a 0.3 percent increase in commuting distance.⁸

⁶ Intracity commuting is a more relevant group if commuting times are compared.

⁷ Calculation: $1.1^{0.147} = 1.014$.

⁸ Calculation: $1.1^{0.035} = 1.003$.

Explanatory Variables	Dependent Variable: Ln distance					
	Model 1: Main effects		Model 2: Interaction effects		Model 3: Structural controls	
Employment density	-.007	(.009)	-.001	(.056)	.014	(.056)
$\ln(\bar{w})$	.147**	(.050)	.127*	(.052)	.142**	(.052)
$\ln(\bar{w})$ * Employment density			-.002	(.012)	-.004	(.012)
$\ln(\Delta w)$	.035***	(.004)	.057***	(.004)	.052***	(.004)
$\ln(\Delta w)$ * Employment density			.011***	(.001)	.013***	(.001)
Unemployment rate					-.003*	(.001)
Change in number of employees					-.328***	(.033)
Constant	1.938***	(.260)	1.958***	(.260)	1.981***	(.268)
Individual controls		✓		✓		✓
ν_r County constant	.381***	(.033)	.410***	(.034)	.381***	(.033)
u_{ir} Person constant	.663***	(.015)	.664***	(.015)	.663***	(.015)
N Counties (level 3)			244			
N Persons (level 2)			1,280			
N Observations (level1)			95,579			

Table 2 Mixed-effects models, Note on significance levels: *** $p \leq 0.001$. ** $p \leq 0.01$. * $p \leq 0.05$
Complete regression table in the appendix

We assumed that this effect is somewhat underestimated because employees would in a first step sort themselves into a place of residence-place of work combination according to their preferences and housing demands and in a second step adjust their commuting distance when changing the job. We assumed that predominantly those residing in areas with a high employment density increase their commuting distance by far, because they are geographically further away from other economic centers and thus from a number of potentially better matching jobs. In that sense, they react more sensitive to incoming job offers. Either they commute very short distances within their own local labor market or they commute very long distances into other labor markets. Employees in rural areas on the other hand, who have intermediate commuting distances, will most likely only slightly adjust their commuting distance when changing jobs. The interaction of the wage change with the centered employment density provides information on the effects in an area with average employment density for the main effect and information to what degree this effect varies with the density.

We observe a slightly lower mean wage effect for employees residing in a region with an average employment density. However, the effect does not vary with employment density. In

essence, irrespective of the place of residence, employees with higher wages commute longer distances. Commuters in urban and rural areas likewise earn higher wages, the longer the commuting distance. The effect of the wage change, however, is higher for employees residing in a region with an average employment density, compared to the average effect in the first model. Moreover, we observe a significantly positive interaction term, indicating that employees residing in areas with a higher density tend to stronger increase their commute for a given wage increase. This finding is in line with our prediction that the sorting process leads to different adjustment processes on the labor market. Depending on where an employee resides, (s)he will increase the commuting distance differently when finding a better match. The magnitude of the effects can be seen in Figure 5 which plots the interaction effects and shows the average wage effect on the relative increase in commuting distance, depending on the employment density. Regarding the graph, it becomes clear that the overall positive effect of a change in wage on a change in commuting distance is mostly driven by employees in dense areas—namely in urban centers.

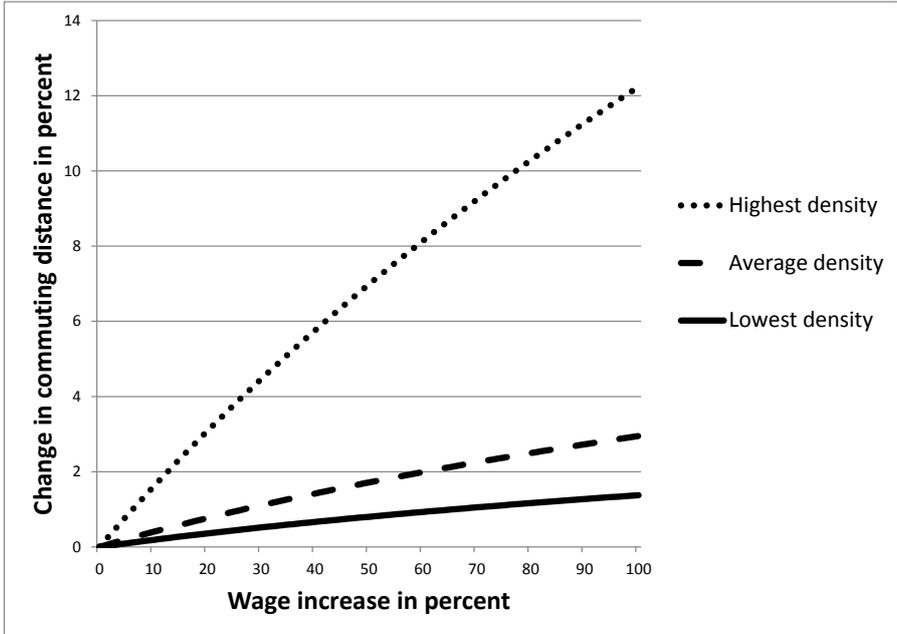


Figure 5 Average effect of a wage change on a change in commuting distance

In model 3, we include structural control variables to test, whether the wage effects hold when the local labor market conditions are taken into account. The change in the number of employees and the unemployment rate are indicators for the local opportunity structure. A higher unemployment rate and a negative change in the number of employees suggest tight labor market conditions. Such labor market conditions could influence the wage effects, because employees might be willing to accept more distant offers when local vacancies are missing. Indeed, the more employees are hired, the shorter are commuting distances. The unemployment rate counteracts to a certain degree, indicating that this effect becomes smaller, the more competition the worker has on

the local labor market. While the labor market conditions have significant effects on commuting distances, they only slightly influence the wage effects. The robust effects indicate that the adjustment due to arriving job offers does not strongly depend on the local labor market. On average, employees are willing to accept longer commuting distances for a wage increase— notwithstanding the local development.

For all models, we estimate significant variance in the person and the county constant, which indicates that further explanations for the length of commuting distances lie on both levels. Other individual and structural factors that we did not explicitly model here seem to influence the accepted travel distance to work. Nevertheless, we obtain some interesting results from our control variables, although the main interest in this study rests on the differential wage effects. Most of the factors are retrieved from migration research, whereas most commuting studies were thus far not able to include such detailed individual information. Surprisingly, some determinants of migration do not hold for predicting commuting distance and vice versa, indicating that commuting and migration are not perfect substitutes and the influences on both decisions underlie different mechanisms.

Age does not have a significant effect on the distance commuted. While age is a strong predictor for migration, commuting distances are not affected. Keeping in mind that migration costs are assessed considering potential life-time income, relative costs rise with age. For commuting this argument does not hold as costs and income surplus are weighted against each other directly. Moreover, we find that—compared to no training—vocational training and especially academic training increase commuting distances. As these cannot be ascribed to potential wage increases, other factors, such as the distribution of jobs or better information through larger networks must be responsible for this finding. Having a partner in the household—either unmarried or married—results in longer commuting distances. The effect should be attributable to dual-earner households that face more difficulties finding appropriate matches at the same location. Furthermore, compared to employees with no children at home, commuting distances for employees with children under three years are shorter. The negative effect might be ascribed to the higher time-demand of in the household. Lastly, contracts with reduced hours seem to lead to longer commuting distances. However, it must be born in mind that this effect is net of wage, which means that for a given daily wage employees with reduced hours would commute longer distances.

Conclusion

Over the past decades, commuting has become increasingly important as a means for labor market adjustment. Identifying the determinants of commuting distances is thus of interest to many social sciences, however by no means straightforward due to complex job and housing decisions. We argued that commuting results from a two-stage process where sorting leads to a temporary optimal

housing/work combination that is adjusted in a second step. Based on urban economic theory, we argued that stronger housing demand leads to the sorting of employees with higher wages into longer commuting distances. Due to changes in the occupational structure, the increase in technology or simply incomplete information, matches are supposedly non-optimal in many cases. These can be dissolved by changing the job. However, due to thin labor markets and thus inconstantly incoming job offers, job opportunities may appear outside the own local labor market, partly resulting in the need to commute further. In such a case, employees residing between economic centers can adjust their commute without having to increase the distance. On the other hand, we supposed employees residing in economic centers to react more sensitive with regard to the commuting distance. Either they commute long distances into other local labor markets or they commute very short distances. Thus we supposed these employees to be responsible for the overall positive effects of wage changes.

To test our assumptions, we focused on commuters who change their job and keep their place of residence. Using a mixed-effects design and matched data from the German ALWA-ADIAB survey, combined with precise wage information from administrative data, we were able to examine the hypotheses concerning wage level and wage increases. First, we find support for the hypothesis that employees with higher wages sort themselves into longer commutes. Second, we find overall positive effects of wage changes on changes in the commuting distance. Indeed—as we assumed—these effects vary greatly by employment density. Employees residing in dense areas are mainly accountable for the positive effect. Thus, labor market-driven adjustments of the working place result in longer commutes only for a subgroup. The positive wage effect on commuting distances, which is found in other studies does not apply to all employees and heavily depends on the residential location. As macro indicators of the local labor market context do not affect the effects we found, we assume that on average, employees seem to be willing to accept longer commuting distances for a wage increase—notwithstanding the local conditions. This may be due to the fact that employees who initially commuted do not find adequate vacancies locally anyways or it may be due to the fact that the probability for wage increases locally is low in any case.

Limitations of this study mainly result from the fact that we are only able to measure the commuting distance with municipality centroids. Employees commuting within cities are thus counted as non-commuters and do not enter the analysis. Several robustness checks, suggest that the mechanisms we found generally hold, however, further research that may be able to draw on geo-coded data and actual travel distances could examine whether within-city commuters follow a different logic. In general, it can be assumed that urban residents have a greater dispersion in the change of the commuting distances due to labor market adjustment. As we have argued, employees

in dense areas will either accept a job nearby or will travel a far greater distance to establish better matches.

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Appendix

	Mean	Std.Dev	Min	Max
Employment density	-1.262	3.148	-3.208	18.370
$\ln(\bar{w})$	4.400	0.495	2.690	5.809
$\ln(\Delta w)$	0.004	0.200	-2.281	1.956
Unemployment rate	9.355	3.954	2.616	27.160
Change in number of employees	-0.017	0.049	-0.302	0.188
Second employment relation	0.069	0.254	0	1
Nationality: German	0.983	0.129	0	1
Education (ref: Lower secondary)				
No degree	0.009	0.097	0	1
Medium secondary	0.377	0.485	0	1
Upper secondary	0.367	0.482	0	1
Second chance education	0.087	0.282	0	1
Family status (ref: single)				
Living with partner	0.128	0.334	0	1
Civil Status: Living with married partner	0.627	0.484	0	1
Formal training (ref: non formal)				
Vocational	0.701	0.458	0	1
Academic	0.262	0.440	0	1
Age in years	36.500	6.735	18.17	52
Sex: Female	0.356	0.479	0	1
Industrial sector (ref: Education, health and other services)				
Manufacturing and agricultural	0.358	0.480	0	1
Public Services	0.052	0.222	0	1
Construction	0.079	0.269	0	1
Trade	0.105	0.306	0	1
Transport	0.030	0.170	0	1
Financial Intermediation and real estate	0.071	0.257	0	1
Working in public sector	0.133	0.340	0	1
Reduced hours (<30h)	0.125	0.331	0	1
Children in the household (ref: none)				
0-3	0.128	0.334	0	1
3-6	0.151	0.358	0	1
Over 6	0.431	0.495	0	1
Partner with higher qualification	0.193	0.394	0	1
East Germany	0.082	0.274	0	1
Residence duration in years	18.870	13.610	0	51.670

Table 3 Descriptive statistics: Observations entering multivariate analyses

Explanatory Variables

Dependent Variable: Ln distance

	Model 1: Main effects		Model 2: Interaction effects		Model 3: Structural controls	
Employment density	-.007	(.009)	-.001	(.056)	.014	(.056)
$\ln(\bar{w})$	.147**	(.050)	.127*	(.052)	.142**	(.052)
$\ln(\bar{w})$ * Employment density			-.002	(.012)	-.004	(.012)
$\ln(\Delta w)$	.035***	(.004)	.057***	(.004)	.052***	(.004)
$\ln(\Delta w)$ * Employment density			.011***	(.001)	.013***	(.001)
Unemployment rate					-.003*	(.001)
Change in number of employees					-.328***	(.033)
Second employment relation	-.093***	(.007)	-.098***	(.007)	-.094***	(.007)
Nationality: German	.084	(.135)	.081	(.136)	.083	(.135)
Education (ref: Lower secondary)						
No degree	-.156	(.182)	-.171	(.182)	-.156	(.182)
Medium secondary	.024	(.054)	.023	(.054)	.024	(.054)
Upper secondary	.030	(.057)	.016	(.057)	.027	(.057)
Second chance education	.037	(.023)	.048*	(.022)	.030	(.023)
Family status (ref: single)						
Living with partner	.029***	(.005)	.032***	(.005)	.029***	(.005)
Civil Status: Living with married partner	.026***	(.005)	.033***	(.005)	.025***	(.005)
Formal training (ref: non formal)						
Vocational	.168**	(.065)	.167*	(.066)	.167*	(.065)
Academic	.424***	(.066)	.438***	(.067)	.429***	(.066)
Age in years	-.002	(.003)	-.002	(.003)	-.002	(.003)
Sex: Female	-.059	(.047)	-.058	(.047)	-.058	(.047)
Industrial sector (ref: Education, health and other services)						
Manufacturing and agricultural	.101***	(.007)	.105***	(.007)	.100***	(.007)
Public Services	.030*	(.013)	.047***	(.013)	.028*	(.013)
Construction	.128***	(.010)	.111***	(.010)	.128***	(.010)
Trade	.059***	(.009)	.060***	(.008)	.062***	(.009)
Transport	-.142***	(.015)	-.126***	(.014)	-.143***	(.015)
Financial Intermediation and real estate	.178***	(.013)	.157***	(.013)	.177***	(.013)
Working in public sector	-.042***	(.008)	-.052***	(.008)	-.042***	(.008)

Reduced hours (<30h)	.132 ^{***}	(.007)	.142 ^{***}	(.007)	.131 ^{***}	(.007)
Children in the household (ref: none)						
0-3	-.026 ^{***}	(.003)	-.027 ^{***}	(.003)	-.026 ^{***}	(.003)
3-6	-.001	(.003)	.002	(.003)	-.000	(.003)
Over 6	-.000	(.004)	-.002	(.004)	-.001	(.004)
Partner with higher qualification	-.035 ^{***}	(.007)	-.042 ^{***}	(.007)	-.032 ^{***}	(.007)
East Germany	-.581 ^{***}	(.021)	-.721 ^{***}	(.020)	-.575 ^{***}	(.021)
Residence duration in years	.001	(.001)	.000	(.001)	.001	(.001)
Constant	1.938 ^{***}	(.260)	1.958 ^{***}	(.260)	1.981 ^{***}	(.268)
Year and month dummies	✓		✓		✓	
ν_r County constant	.381 ^{***}	(.033)	.410 ^{***}	(.034)	.381 ^{***}	(.033)
u_{ir} Person constant	.663 ^{***}	(.015)	.664 ^{***}	(.015)	.663 ^{***}	(.015)
N Counties (level 3)			244			
N Persons (level 2)			1,280			
N Observations (level1)			95,579			

Table 4 Complete mixed-effects models, Note on significance levels: *** $p \leq 0.001$. ** $p \leq 0.01$. * $p \leq 0.05$