

Haas, Anette; Reichelt, Malte

**Conference Paper**

## Do you commute further for extra money? Region specific income effects on commuting distances

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## **Do you commute further for extra money? Region specific income effects on commuting distances**

Draft version, July 24, 2014, please do not quote

### **Abstract**

*Over the past decades commuting distances in Germany have steadily risen, although commuting costs increased over-proportionally. Explaining such phenomena is not straightforward, as urban economic theory predicts increasing commuting distances for higher income. Arguing with occupational specialization, residential inertia and mono- as well as polycentric labor markets, we assume regionally diverse commutes and differential income effects on distances. Using a mixed-effects design and retrospective life-course data from the German ALWA-ADIAB survey, we show that commutes rise from urban to rural areas. However, first and foremost employees residing in urban areas increase their relative commuting distance for higher income. In rural areas, where appropriate jobs are rare, overall longer distances into economic centers seem to prohibit a positive income effect. The results support the finding that the increased commuting distances in Germany can mainly be ascribed to a change in commuting behavior of urban and suburban residents.*

### **Introduction**

Over the past decades, commuting distances in Germany have steadily risen, indicating an increase in mobility among the German workforce. The percentage of employees with different counties of residence and work has been rising from 31 percent in 1995 to 39 percent in 2005 (Haas and Hamann, 2008). Moreover, commuting distances seem to be increasing. While 14 percent of all employees exhibited a commuting distance above 25km in 1996, the share grew up to 17 percent in 2004 (Einig and Pütz, 2007), hence a growing share of employees commutes particularly long distances. The trend is as well reflected in average commuting distances, which grew from 14.6 km in 1999 to 16.6 km in 2009 (BBSR, 2012). This is rather surprising as relative commuting costs have increased at the same time. Moreover, the change cannot be ascribed to a change in the mode of transportation. Every four years, there is a supplementary survey about commuting behavior of households in the microcensus (Mikrozensus), including working population, students, and pupils. Questions contain distance between the residence and the workplace, the amount of time required for a commute and the most commonly used means of transportation. The means of transportation

depends on individual preferences, monetary and time costs and the provided infrastructure. Results in 2012 indicate that 66% used cars, 14% public transport, 9% each for bicycle or walking. Spatial pattern matters, the car dominates in rural areas (72.1%) vs. core cities (49.4%). Considering information in 2004, 2008, 2012, we detect only minor changes in the choice of transport mode, a shift far away from car use is not observable.

A comparison of wages and costs for transportation reveals that real wages even declined by 2.1 percent between 2002 and 2010, while transportation costs show an increase of almost 22 percent.<sup>1</sup> This phenomenon evokes the question on determinants of commuting distances. Why does commuting distance increase despite seemingly worse conditions?

As commuting usually is employment-related, income stands in the center of many explanations. Urban economic theory predicts that higher income should lead to longer commuting distances as the optimal place of residence is chosen, optimizing land rents and commuting costs (Alonso, 1964; Muth, 1969). Indeed, moderate income effects on commuting distances can be found, stating that an increase in wage leads to longer distances between place of work and living (Abraham and Nisic, 2007; Groot *et al.*, 2012; Gutiérrez-i-Puigarnau and Van Ommeren, 2013). However, a simultaneous increase in commuting distances and costs suggests that the income effect might not be as clear-cut as assumed. Demarcating the same effect for all employees might then be substantially wrong and after all, the increase in overall commuting distances might be ascribed to a specific group.

We argue that due to the structure of mono- and polycentric labor markets employees per se have different commuting distances. While urban residents commute relatively small distances, commuting pathways for residents in rural areas should be substantially longer. In agglomerations (Rhein-Ruhr, Rhein-Main, Stuttgart, München, 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 (Wingarter, 2014).

Temporally optimal combinations of place of work and residence might then be altered in a sequential manner if income gains are achievable elsewhere, leading to an increase in individual commuting distances. The relative increase in commutes, however, then differs according to the commuting distance beforehand. Distance growth should matter most for urban residents, as they commuted small distances before and matter least for rural residents who per se commuted longer distances. Against the intuition, the income effect on commuting distance should thus be largest for urban residents and smallest for rural residents.

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<sup>1</sup> Increases calculated from indices of real wages and consumer price indices for transport total, including motor cars, fuels and lubricants, maintenance and repair as well as transport services (Statistisches Bundesamt, 2013, 2014).

These assumptions hold implications not only for individual income effects, but may contribute to explaining macro-phenomena such as the general increase in mobility. We use retrospective data from the survey ALWA-ADIAB to test if the income effect on commuting distance varies by regional type. Moreover, using process data from the German Federal Employment Agency, we demarcate developments in key figures on regional commuter shares and distances to examine if the predictions are reflected in macro developments. In the following, we will take the individual's commuting decision as given. The goal of this research is not to contribute to the discussion about the determinants of a commuting *decision*, but rather to evaluate how a change in income affects the commuting *distance*.

The paper is structured as follows. First, we elaborate the theoretical background from which we derive hypotheses on the income effect on and macro developments of commutes. Second, we describe our analytical strategy, including our approach to identify the causal income effect 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 further steps.

## **Theoretical background**

### **Urban economic theory and labor markets**

Studies on commuting behavior usually observe two trends: On the one hand more employees decide to start commuting and on the other average commuting distances have been growing. From a labor market perspective workers should 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. Several theoretical approaches try to explain the location combinations that emerge.

Following urban economic theory households choose their residential location to maximize their utility, balancing the increased costs of commuting against the advantages of cheaper unit price of land (Alonso, 1964; Brueckner, 2000; Muth, 1969). In spatial equilibrium all workers are thus fully compensated for longer commutes by lower housing costs.<sup>2</sup> 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. Every place of work and place of residence combination exhibits the same utility and there would be no incentive to switch jobs or change residence.

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<sup>2</sup> A detailed discussion about the spatial equilibrium concept in urban economics can be found in (Glaeser and Gottlieb, 2009; Puga, 2010).

Some phenomena, however, cannot be explained following these classic assumptions.<sup>3</sup> On the German labor market, one can observe cross and excess commuting (Horner and Murray, 2002) or—as described in the beginning—increasing commuting distances and disproportionately growing mobility costs. Moreover, observed commuting distances generally exceed those predicted by standard models of household location choice.

Explanations for increasing mobility are manifold and encompass heterogeneous preferences, residential amenities (Ng, 2008) or reverse commuting due to regional decentralization<sup>4</sup> (living in cities and working in suburbs). Empirical evidence as well suggests the relevance of cross commuting in cities (Hamilton and Röell, 1982; Small and Song, 1992) and it becomes evident that both urban and labor market factors have to be considered. Indeed, Moretti (2011) stresses the intersection between urban and labor economics as being fundamental for understanding the functioning of local labor markets. While theoretical urban models assume that the residence location is endogenous (White, 1988), labor models assume that it is given (Rouwendal, 1999). Moreover, recent research has provided convincing evidence that workplace accessibility influences housing prices (Ahlfeldt, 2011; Osland and Thorsen, 2008), as well stressing the interrelationship of labor market and residence location.

A major argument for considering both aspects is that economic activity is strongly concentrated in space. It is widely accepted in urban economics that larger and dense labor markets are favorable for workers and firms. Densely populated areas attract firms and workers, because they are more productive and thus pay higher wages. According to Duranton and Puga (2004), the micro-foundations of urban agglomeration economies could be explained by sharing, matching and learning. Firms and workers profit by sharing a labor market pool, improving the quality of matches and accumulating human capital. Thus, economic activity is dense in urban and suburban centers and influences employment prospects as well as choice of residence and thus commuting decisions.

### **Regionally diverse commuting distances and income effects**

We as well consider both—arguments from urban and from labor economics—and derive hypotheses concerning overall commuting distances and income effects on changes in these. We pick up urban economic theory and further assume (1) sequential optimization of place of work and residence, (2) occupational specialization and (3) mono- and polycentric sub-labor-markets. We then obtain differential predictions on regional income effects and overall commuting distances.

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<sup>3</sup> (Wrede, 2014) analyses urban spatial patterns in continuous space in a closed polycentric city with one or more business centers in given locations with a continuous logit model framework. If location choices are probabilistic, the deterministic part of equilibrium utility varies across locations. Compensating for differences in the deterministic aspect of the utility is only partially necessary. With probabilistic choices, a small fraction of workers accepts incomplete compensation for additional commuting costs.

<sup>4</sup> See e.g. (Travisia *et al.*, 2010) for the phenomena of urban sprawl.

As outlined above, commuting distances will occur when workplace and place of residence are not chosen in the same location. We argue that even if an initial combination might be chosen optimally so that lower housing prices compensate for increased commuting costs, a change of jobs may lead to non-optimal combinations from an aggregate perspective and an increase in commuting distance, resulting in sequential optimization. Over the life course, accumulation of human capital and changing information on labor market opportunities may open new possibilities to increase one's own income by changing jobs. These may very well lie outside one's own region. A long commuting distance between place of residence and workplace might trigger an employee to switch employers instead of moving geographically, or vice versa. Households might be reluctant to migrate if other members of their family could be negatively affected by a residential move. Residential mobility costs are determined by the composition of their families, family ties, and by the attachment to the present dwelling. This suggests that the utility which an employee derives from changing jobs increases with the commuting distance between the employee's place of residence and current workplace. Some papers try to prove that the optimization of individuals choosing location and residence lies in a specific order (Clark *et al.*, 2003; Patacchini and Zenou, 2005; Rouwendal and Rietveld, 1994; van Ommeren *et al.*, 1999; Zax, 1991). A sequential optimization – first job than housing - seems more appropriate compared to a simultaneous job and housing search.

The process of occupational specialization and polarization, which leads to a growth in highly specific jobs (Autor, 2013) supports this argument: The probability to achieve better matches and thus to increase one's productivity and income in another region rises, simply because specialization reduces the chance to find perfect matches locally.

Given such employment opportunities, several circumstances suggest that employees are usually interested in keeping their places of residence, when taking on another job. 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 with differential commuting distances. Further, the labor market postulates a higher spatial and temporal flexibility of the employees during the last years, so a job change does not imply a change of residence. The assumptions are supported by rising numbers of commuters versus stagnating numbers of relocations (Kalter, 1994). Given the development of specialization and given a preference for at least some employees to keep the place of residence constant and commute instead of migrate, the *overall share* of commuters should thus increase.

To attain implications on *commuting distances*, however, one has to account for the spatial structure of the labor markets. As described above, the German labor market is consistent of mostly mono-

and polycentric sub-labor markets. Most commuting pathways lead into economic centers and thus into urban areas—cities and their surroundings. As outlined above, agglomeration economies foster higher wages in urban centers, as well supporting this argument. This leads to a simple implication: Commuting distances rise from urban to rural areas. Furthermore, because of the advantages of agglomeration effects explained above, the majority of jobs, especially highly specific ones, which yield the possibility of high income gains, should be found in economic centers and thus in urban areas. Indeed, it can be shown that for the U.S. specialization led to an increased concentration of highly specific thought, communication and inter-social activity tasks in metropolitan areas (Michaels *et al.*, 2013).

Combining the assumptions, we can obtain implications on the *income effect on commuting distance*. On average, the commuting connection between two urban centers should be longer than pathways from any other region into the metropolitan area. Accepting an employment relation in an urban area should thus not result in overly longer commutes for rural residents. Moreover, assuming that employees who are already residing in urban areas usually dispose of a well-functioning local labor market with alternative job opportunities, possible income gains must be particularly large to increase the distance. As residents in urban areas should have the shortest initial commutes, a possible change in income should thus lead to the largest relative change in commuting distance. For residents in rural areas, who per se have a longer commute, a change in income will not necessarily result in longer distances if another economic center is chosen. Anyhow, the relative increase in distances should be lowest. The local labor market condition however, such as the development of employment or the unemployment rate, should mediate the relationship.

We thus expect increasing commuting distances and a decreasing income effect from urban to rural areas. First and foremost commuters residing in urban areas should be responsible for an overall positive income effect. On an aggregate level, the processes of increasing rental prices as well as increasing specialization and labor market flexibilisation should lead to growing shares of commuters in all regions. Increasing commuting distances, however, should mostly result from longer commuting distances of urban and suburban residents, for whom it becomes profitable to commute into other economic centers.

## **Analytical strategy**

### **Addressing reverse causality**

Trying to identify the causal effect of income on commuting distance is not straightforward due to complex interactions (Haas and Osland, 2014) and reverse causation (Gutiérrez-i-Puigarnau and Van Ommeren, 2013). On the one hand, higher income may provide the possibility of realizing preferences and thus of choosing a place of residence farther away from the employer location. On

the other, employers may reimburse employees for commuting longer distances, thus leading to a causal effect of commuting distance on income.

So far, 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 good instrumental variables that do have an influence on income but do not influence workplace location (Manning, 2003). Gutiérrez-i-Puigarnau and Van Ommeren (2013) offer another approach in which they select those employees that keep the employer constant and change the place of residence during the work spell. By comparing the first and last income measurement, they are able to calculate the effect of income differences on differences in commuting distances. A problem that arises with this approach, however, is that temporal information within episodes is ignored, which may lead to problems especially in longer employment spells. Moreover, the group that changes the place of residence within an employment spell may consist of employees that will optimize living conditions and start commuting that is not labor market driven.

Trying to identify the effect of income on commuting distance, we offer another approach. Discarding employees with the highest bargaining power will most likely eliminate incidences, in which increases in commuting distances can be ascribed to commuter-reimbursement. 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 (Brenzel *et al.*, 2013; Wallerstein *et al.*, 1997). However, employers might be forced to compensate for commuting costs if appropriate labor supply is low.

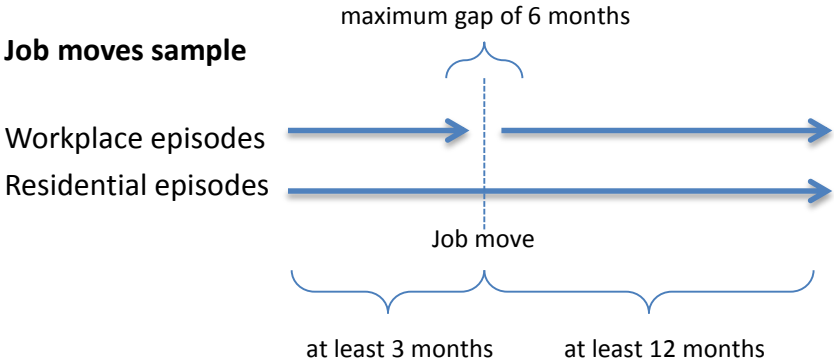


Figure 1 Sample selection



We thus exclude employment episodes that are connected to highly complex tasks and an executive position—meaning at least one subordinated employee.<sup>5</sup>

Second, we draw on longitudinal data that allows us to select the most current employment episode with a job change. As shown in Figure 1 the sample encompasses constant residential episodes with a change of the employer within. 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. With keeping only such episodes, we should obtain labor market driven changes in commuting instead of changes in place of residence due to the housing market or other for other reasons. Without having to consider relocation costs, commuting distances should be chosen according to potential wages. 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.

### Statistical Method

The aim of this paper is twofold, as we first examine regional differences in commuter shares and commuting distances and second identify the regionally dependent income effect on commuting distance in a microeconomic analysis. For the first question, we draw on simple graphical comparisons. To answer the latter question, we calculate the effect of the logarithm of wage on the

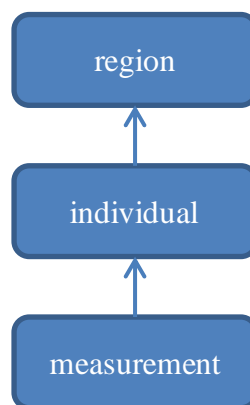


Figure 2 Classification diagram

logarithm of commuting distance using mixed-effect panel regressions.

Selecting the most recent job switch in the individual career, we obtain longitudinal data with constant places of residence. We thus face a data structure in which panel measurements are nested within individuals and these are nested within regions, as shown in the classification diagram in

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<sup>5</sup> For robustness checks, we calculate our analyses including and excluding the group of potential bargainers.

Figure 2. Measurement occasions then may not be independent from unobserved individual and regional factors.

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 region-type-specific income effects on commuting distances. A major advantage of the method is the possibility to estimate both—fixed and random effects, which are both of interest. 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:

$$y_t = \beta_1 w_{1ij} - w_j + \beta_2 w_j + \beta_3 x_t + \delta_{ind\ t}^2 + \delta_{reg(t)}^{(3)} + \epsilon_t$$

With

$$\delta_{ind\ t}^2 \sim N(0, \sigma_{\delta^2}^2),$$

$$\delta_{reg\ t}^3 \sim N(0, \sigma_{\delta^3}^2),$$

$$\epsilon_t \sim N(0, \sigma_{\epsilon}^2),$$

where  $y_t$  is a commuting measurement for month  $t$  for a given individual  $ind$  in a given region  $reg$ .  $\beta_3 x_t$  and  $\beta_1 w_{1ij} - w_j + \beta_2 w_j$  indicate the fixed part of the regression, while the random part consists of a random intercept  $\delta_{ind\ t}^2$  for individuals and  $\delta_{reg(t)}^{(3)}$  for regions and the individual residual  $\epsilon_t$  at measurement point  $t$ , conditioned on the individual and the region random effect. Separating the wage effect using Mundlak's formulation, we obtain a measure for the within effect of income on commuting distance  $\beta_1$  and a between effect of income on commuting distance  $\beta_2$ . The former represents the same effect we would obtain in a fixed-effects model while the latter represents an "endowment" effect or the effect of wage on the initially chosen commuting distance. However one has to be careful interpreting this effect as the combination of place of residence and work may have been realized for whatever reason. Arguing with sequential optimization, the within effect would be the optimization of the commuting distance for a specific change in income while the between effect would indicate the formerly optimal wage-distance combination.

## Data

### Datasets

In our analyses, we use two distinct data sources as well as context information that we link to the datasets. For descriptive results on macro developments of commuting shares and distances, we

draw on process data from the German Federal Employment Agency (BA), made available through the Sample of Integrated Labour Market Biographies (SIAB) (Dorner *et al.*, 2010). For the years 2000 until 2009, we select information for the reference month June and use data on place of work and residence.

For the micro-econometric analysis we draw on retrospective data from the ALWA-ADIAB survey, which is available through the Institute of Employment Research (IAB). The survey was conducted in 2007/2008 and includes 10,177 retrospective computer assisted telephone interviews (CATI) that encompass monthly residential, work place, educational, employment and partnership histories in Germany and is linked to process data from the BA (Antoni *et al.*, 2011). It contains a broad set of cross-sectional variables that focus primarily on education and human capital. The sample is representative for Germany and covers people born between 1956 and 1988 (Kleinert *et al.*, 2011).<sup>6</sup> Furthermore, the survey is linked to process data of the BA, which allows us to consider income information on a monthly basis.

We additionally link regional data from the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) to both datasets including regional type and distance measures. The latter is used to define commuters and commuting distance, as we employ the distance between the centers of residence and employer municipality.

### **Operationalization**

Three constructs are at the heart of this analysis: Income, commuting distance and region types. The former is measured as the *logarithm of daily wage*, retrieved through process data of the BA for all employees that are subject to social insurance contributions. The income data is linked to the ALWA survey on a monthly basis, achieving a high level of validity. In order to deflate the income and to obtain a comparable measure, we adjust the income to the consumer price index. The *distance* is measured as the logarithm of street distance between municipality-centers of place of residence and place of employment and is obtained through the BBSR. Using the same source, we obtain four spatial types that are mainly based on population density in 363 county-regions.<sup>7</sup> Urban districts encompass cities of at least 100,000 inhabitants. Wider urban areas are counties with at least 150 inhabitants per square kilometer and at least 50 percent living in large and medium sized cities. High density rural areas are counties with a population density lower than 150 inhabitants per square

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<sup>6</sup> The ALWA survey incorporates post-stratification weights that adjust for non-response. Sample weighting, however, is a yet unresolved issue in mixed-effects models (Gelman, 2007). Moreover, we would assume random non-response corresponding to the factors used for the adjustment. For robustness checks, however, we calculated pooled OLS regressions with and without weights. The parameter differentials yield no substantial differences in both regression designs so that we assume ignoring weights for our analyses is legitimate and more efficient than implementing them.

<sup>7</sup> Counties and region types are matched according to the spatial status from 31.12.2008 and are retrospectively assumed constant.

kilometer and at least 50 percent living in large and medium sized cities as well as counties with a population density of at least 100 inhabitants per square kilometer without large and medium cities and less than 50 percent living in such cities. Low density rural areas are counties with less than 50 percent living in large and medium sized cities and a population density lower than 100 inhabitants per square kilometer (BBSR, 2012).

Table 1 shows a description of distances and income for the complete sample and for the four region types. The sample size is restricted to observations with complete income and distance data as both must be given for the multivariate analysis.

	Obs.	Indiv.	Distance in km				Daily wage in EUR			
			Mean	Std.Dev.	Min	Max	Mean	Std.Dev.	Min	Max
Overall	191,552	2,187	11.64	18.16	0.00	188.91	89.70	61.83	11.44	978.78
Urban district	58,027	680	6.54	15.58	0.00	164.47	96.39	63.69	12.61	850.48
Wider urban area	86,985	985	13.98	18.01	0.00	188.91	92.57	64.09	11.44	730.20
High density rural area	21,802	249	17.62	22.46	0.00	133.55	80.92	51.45	12.28	978.78
Low density rural area	21,853	242	11.10	17.69	0.00	145.55	72.25	54.87	11.77	975.97

Table 1 Commuting distance and Income by spatial type

Our main 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*.<sup>8</sup> *Vocational and academic training* is controlled for by two dummies in reference to no vocational or academic training. Civil status is classified as living in a household without a partner, an unmarried partner and a married partner. Children in the household are differentiated between age groups. Groups encompass 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

<sup>8</sup> 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.

variable for the duration of residence in years. 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.

### **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, as income measurements for East Germany is 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 with 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 causal effect of income 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.

## **Empirical Results**

### **Descriptive evidence**

Based on our deliberations on the structure of sub-labor-markets, occupational specialization and residential inertia, we assumed an increase in commuter shares in all regional types as well as an increase in commuting distances predominantly for residents in urban areas. Before turning to the influences on commuting distance, we thus examine macro developments of commuting in Germany. Figure 3 shows the share of commuters and the average commuting distance by regional

type that is calculated using the SIAB dataset. We restrict the timeline to the years 1999 to 2009 for reasons of comparability with the numbers described above. The commuter shares are defined as the ratio of commuters beyond county borders to all employees residing in a specific regional type.

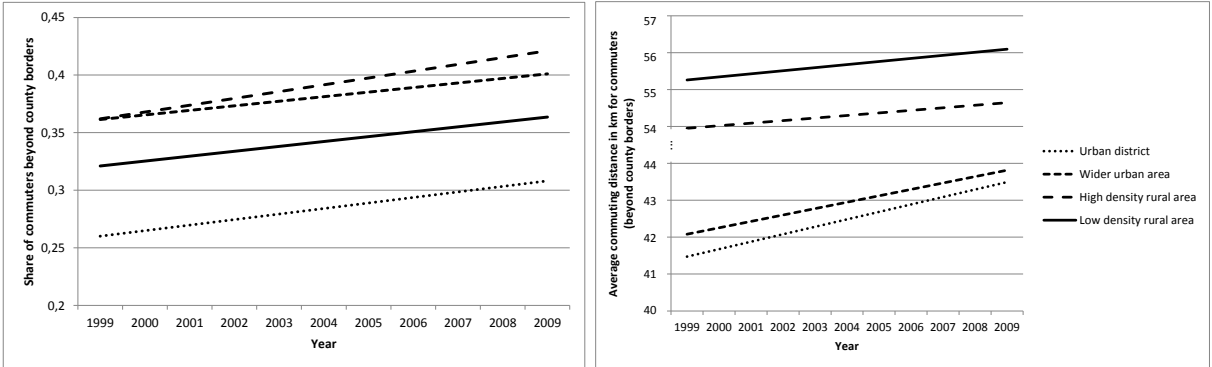


Figure 3 Share of commuters and average commuting distance from 2000 to 2009 by regional type (linear trend)

The average commuting distance gives information on the distance between centers of workplace and residence county for this population.

First turning to the overall shares, the trend lines in left-hand graph show the assumed development. Confirming findings of other studies, the shares of commuters are rising—again, despite an increase in commuting costs during the same time. Moreover, we stated that the development should hold for all employees, irrespective of their place of residence. Despite slight differences in growth curves, this assumption can be confirmed as well. The right hand graph shows the average commuting distance for those employees that commute beyond county borders. The distance increases for commutes in all types of regions. However, as we supposed, the increase is largest for urban residents: While commutes in rural areas show a maximum increase between 0.5 and 1 kilometer, both commuting distance for residents in wider urban areas and in urban districts increases by about 2 kilometers. This can as well be seen in the ALWA-ADIAB data. Table 2 shows that with a change of job, the distance is increased for urban and wider urban residents whereas it is even decreased for rural residents. Thus, the increase in overall commuting distance can be ascribed to both—an increased share of commuters and increasing distances, mainly for residents in urban areas, again stressing the question of determinant of commuting distances.

The third prediction was strictly increasing commuting distances from urban to rural areas. Indeed, commuting distances show the expected order, supporting the assumption of monocentric labor markets.<sup>9</sup>

<sup>9</sup> Surprisingly, Table 1 shows a different pattern for commuting distances in the ALWA-ADIAB survey data. Against our assumption and against the here presented findings, commuters in low density rural areas do not exhibit the longest commutes. However, this finding may be resultant of a selective commuter-group composition for this regional type. It is conceivable that the survey data for instance encompasses rural

		Average change in distance (km)			
		Mean	Std.Dev.	Min. (max reduction in distance)	Max. (increase in distance)
Starting region	Urban district	0.30	19.74	-132.46	164.47
	Wider urban area	0.19	19.11	-116.34	128.30
	High density rural area	-0.39	19.71	-95.92	78.69
	Low density rural area	-0.21	17.40	-76.90	127.85
Overall		0.12	19.04	-132.46	164.47

Table 2 Average change in distance with job change

### Multivariate evidence

The descriptive results mainly support our assumptions on macro developments, as commuter shares are rising and commuting distances are increasing especially for urban residents. Moreover, we see the expected difference in commuting distances due to monocentric labor markets. For a more detailed analysis we deploy multivariate analysis, focusing especially on income effects and regional differences in commuting distances. We apply mixed-effect panel regressions to analyze the effect of the logarithm of wage on the logarithm of commuting distance and the regional differences in the logarithm of commuting distances. Table 3 shows a main and an interaction effects model and gives information on the influences on commutes for all employees (excluding potential bargainers) that keep their place of residence constant and change the workplace at least once.<sup>10</sup>

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commuters that are mostly employed in specific industries or jobs that are not primarily situated in urban centers.

<sup>10</sup> For robustness checks, we included analyses excluding potential bargainers. The results do not differ substantially.

Explanatory Variables	Dependent Variable: Log distance					
	Main effects model			Interaction effects model		
	$\beta$	95% CI		$\beta$	95% CI	
<b>Context level</b>						
Ref: Urban district						
Wider urban area	-0,154	( -0,318	0,010 )	-1,003*	( -1,967	-0,039 )
High density rural area	0,090	( -0,114	0,293 )	-0,561	( -1,826	0,703 )
Low density rural area	0,030	( -0,184	0,245 )	-0,318	( -1,597	0,962 )
<b>Cross level interaction</b>						
Groupmean centred wage [ $\log(\Delta w)$ ]						
Ref: Urban district * $\log(\Delta w)$	0,036***	( 0,029	0,044 )	0,124***	( 0,107	0,141 )
Wider urban area * $\log(\Delta w)$				-0,108***	( -0,127	-0,089 )
High density rural area * $\log(\Delta w)$				-0,062***	( -0,088	-0,037 )
Low density rural area * $\log(\Delta w)$				-0,163***	( -0,192	-0,133 )
Groupmean wage [ $\log(\bar{w})$ ]						
Ref: Urban district * $\log(\bar{w})$	0,149**	( 0,054	0,243 )	-0,326**	( -0,534	-0,118 )
Wider urban area * $\log(\bar{w})$				0,631***	( 0,404	0,859 )
High density rural area * $\log(\bar{w})$				0,541***	( 0,242	0,841 )
Low density rural area * $\log(\bar{w})$				0,569***	( 0,260	0,878 )
<b>Model summary</b>						
$\delta_{reg(t)}^{(3)}$ region constant	0,370***	( 0,312	0,440 )	0,373***	( 0,314	0,443 )
$\delta_{ind(t)}^{(2)}$ person constant	0,663***	( 0,636	0,692 )	0,662***	( 0,635	0,691 )
N Regions (level 3)				254		
N Persons (level 2)				1,369		
N Observations (level1)				102,015		

Explanatory Variables	Dependent Variable: Log distance					
	Main effects model			Interaction effects model		
	$\beta$	95% CI		$\beta$	95% CI	
<b>Controls</b>						
Formal education (ref: lower secondary)						
No degree	-0,057	( -0,393	0,280 )	-0,062	( -0,399	0,275 )
Medium secondary	0,037	( -0,067	0,140 )	0,041	( -0,063	0,144 )
Upper secondary	0,031	( -0,079	0,141 )	0,035	( -0,075	0,145 )
Second chance education	0,040~	( -0,005	0,085 )	0,039~	( -0,006	0,084 )
Training (ref: none)						
Vocational	0,164 *	( 0,038	0,290 )	0,145 *	( 0,019	0,271 )
Academic	0,403 ***	( 0,275	0,531 )	0,385 ***	( 0,257	0,513 )
Civil Status (ref: single)						
Partner in household	0,030 ***	( 0,021	0,039 )	0,030 ***	( 0,021	0,039 )
Married partner in household	0,026 ***	( 0,017	0,035 )	0,025 ***	( 0,016	0,034 )
Child in household (ref: no child)						
Under 3	-0,039 ***	( -0,045	-0,033 )	-0,039 ***	( -0,045	-0,033 )
3-5	-0,014 ***	( -0,019	-0,009 )	-0,013 ***	( -0,018	-0,008 )
6+	-0,006 ~	( -0,013	0,001 )	-0,006	( -0,012	0,001 )
Higher education of partner	-0,028 ***	( -0,042	-0,014 )	-0,028 ***	( -0,042	-0,014 )
Reduced hours (<30h)	0,063 ***	( 0,049	0,076 )	0,062 ***	( 0,049	0,076 )
Second employment relation	-0,062 ***	( -0,075	-0,049 )	-0,063 ***	( -0,076	-0,050 )

Explanatory Variables	Dependent Variable: Log distance					
	Main effects model			Interaction effects model		
	$\beta$	95% CI		$\beta$	95% CI	
<b>Controls</b>						
Female	-0,060	( -0,149	0,028 )	-0,057	( -0,146	0,031 )
Age	0,000	( -0,006	0,005 )	0,000	( -0,006	0,006 )
Nationality: German (ref: other)	0,063	( -0,193	0,318 )	0,067	( -0,189	0,322 )
Public Sector (ref: private sector)	-0,021 **	( -0,037	-0,005 )	-0,021 ***	( -0,037	-0,005 )
Industrial sector (ref: Education, health and other services)						
Manufacturing and agricultural	0,168 ***	( 0,154	0,182 )	0,166 ***	( 0,152	0,180 )
Public service	0,124 ***	( 0,099	0,149 )	0,121 ***	( 0,096	0,147 )
Construction	0,165 ***	( 0,146	0,184 )	0,164 ***	( 0,145	0,183 )
Trade	0,091 ***	( 0,075	0,108 )	0,089 ***	( 0,073	0,106 )
Transport	-0,097 ***	( -0,126	-0,068 )	-0,097 ***	( -0,126	-0,068 )
Financial intermediation and real estate	0,207 ***	( 0,181	0,234 )	0,206 ***	( 0,180	0,233 )
East Germany	-0,479 ***	( -0,515	-0,442 )	-0,498 ***	( -0,535	-0,461 )
County UE rate	-0,002 **	( -0,004	0,000 )	-0,003 ***	( -0,005	-0,001 )
County changes in employment	-0,003 ***	( -0,004	-0,003 )	-0,003 ***	( -0,004	-0,003 )
Residence duration in years	0,001 *	( -0,001	0,002 )	0,001	( -0,001	0,002 )
Intercept	1,932 ***	( 1,932	1,932 )	2,579 ***	( 1,657	3,500 )

Further controls encompass: Calendar dummies, year dummies, Note on significance levels: \*\*\* p<0.001. \*\*p<0.01. \*p<0.05

Table 3 Mixed-effects regressions



102,015 observations enter the analysis, belonging to 1,369 employees that reside in 254 counties. We first focus on the income effect on commuting distance and examine the main effects model. We obtain a highly significant income elasticity of the groupmean centered wage of 0.036, which indicates the same effect, we would obtain in a fixed-effects model. This result is in line with other research, emphasizing positive effects of an increase in individual or household income on distance or commuting time (Abraham and Nisic, 2007; 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 100 percent increase in income would lead to a 2.5 percent increase in commuting distance.<sup>11</sup> Given an average commute of about 17 kilometer, a 100 percent wage increase would thus lead to an increase of about 420 meters. The effect of the groupmean wage is by far larger, indicating that initially those with higher income commute further—in line with the argumentation of urban economic theory that due to a greater demand for housing, employees with high income chose places of residence farther away from their workplace. A little surprising is that the region type itself has no significant influence, which means that adding all control variables the differences in commuting distances between regions vanish. However, this might be ascribed to the fact that commuters with higher income commute further when residing outside the urban regions.

In the second model, we add interaction effects of income and region type. We can now test the assumption of differential income effects between regions. Compared to the reference group mean centered income effect for urban residents, which is now 0.124, all other income effects are smaller and the difference in income effects between rural as well as wider urban areas and urban districts is highly significant. For illustration: For a 100 percentage change in income, urban residents change their distance by about 8.6 percent, while rural residents even reduce their distance by 2.7 percent. Employees residing in high density rural areas or in wider urban areas show income effects in between. The magnitude of the effects can be seen in Figure 4 which plots the interaction effects and shows the average wage effect on the relative increase in commuting distance. The differential effects support our assumption that residents in urban districts will change their commuting distance to the largest amount. However, for residents of wider urban areas and high density rural areas, the effect is not as clear cut as expected, indicating that the assumption of mono- and polycentric labor markets may be too restrictive.

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<sup>11</sup> Calculation:  $2^{0.036} = 1.0025$ .

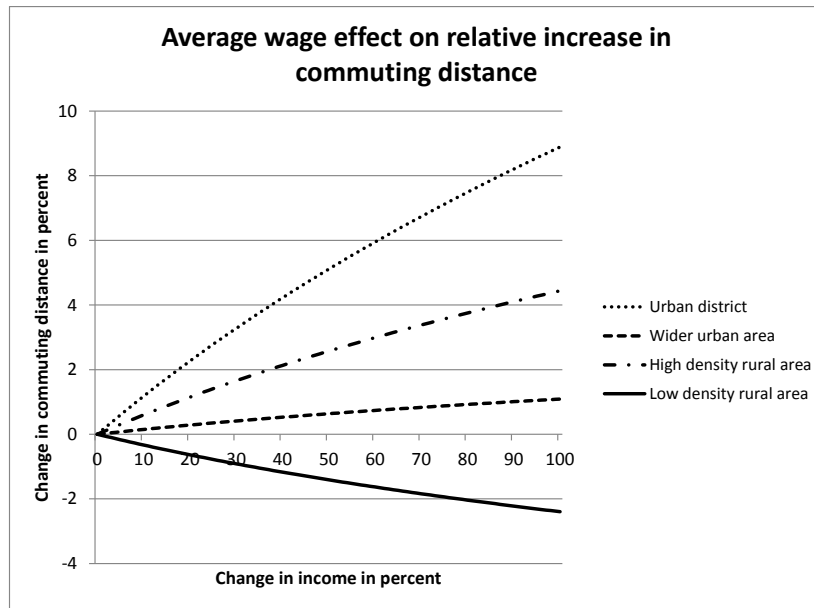


Figure 4 Change in income on change in commuting distance by regional type

The explanation for regionally diverse commuting distances is to a large part based on geographic and structural assumptions. We were arguing that due to monocentric labor markets counties with a lower population density lie farther away from economic centers.

As we estimate significant variance in region constants, however, we know that there are further properties of counties that influence the commuting distance and are not explained through the regional type. We therefore included the county unemployment rate and the change in employment per county. Both have a significant effect—while a higher unemployment rate surprisingly leads to lower commuting distances, a reduction in employment leads to longer distances. However, both variables do not seem to alter the region specific income effects, when calculating nested models. A reason may be that the indicators do not fully capture the local opportunity structure.

The same logic applies to the variance in person constants. Besides the variation in commuting distance that we are able to explain with our influencing and our control variables, there is unobserved heterogeneity within the persons. However, we obtain some very interesting results from our control variables, although the main interest in this study lies on the differential income 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. For instance 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 income gains, other factors, such as the distribution of jobs or better information through larger networks must be responsible for this finding. Both, having a partner in the household—unmarried or married—results in longer commuting distances. Especially for dual-earner household it becomes difficult to find appropriate matches at the same location. Furthermore, compared to employees with no children at home, commuting distances for employees with children are shorter. The negative effect might be ascribed to the higher time-demand of in the household. Lastly, one finding that at first sight contradicts previous studies is that 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.

While we were able to explain different income effects and differences in commuting distances based on the place of residence, further research will be needed to disentangle the mechanisms behind the additional individual effects that we found in our analyses.

## **Conclusion**

We start referring to the striking phenomena that over the past decades commuting distances in Germany have steadily risen, although commuting costs increased over-proportionally. This is surprising, as urban economic theory predicts increasing commuting distances especially for higher income, which indicates that either other factors must drive the increase in commuting distances or the income effect may not be as general as so far assumed.

We pick up urban economic theory and assume sequential optimization of place of work and residence, occupational specialization and a structure mono- and polycentric sub-labor-markets. Based on these assumptions, we obtain differential predictions on regional income effects and overall commuting distances, which can as well be an explanation for the increasing commuting distances on an aggregate level.

To test our assumptions we use both—process data from the German Federal Employment Agency and retrospective life-course data from the German ALWA-ADIAB survey. We draw on the former to show that indeed macro developments of commuter shares and distances match our assumptions and the latter to analyze the determinants of commuting distance on an individual level, focusing especially on the income effect. Identifying the income effect is not straightforward, as employers may reimburse employees for commuting longer distances, thus leading to a causal effect of commuting distance on income rather than vice versa. We account for endogeneity with sensitivity

analyses excluding the group of employees who have the highest bargaining power and show that reverse causality does not seem to be a major issue. Income effects do not substantially vary excluding or including this specific group.

Descriptively, we can show that commuting distances rise from urban to rural areas. Using a mixed-effects design to disentangle time variant and constant effects for both, individuals and regions, we show that first employees with higher income reside further away from their workplace. Second, we show that a possible change in income results in a small further increase in commuting distance—supporting the assumption of sequential optimization. Third, we show that predominantly employees residing in urban areas increase their relative commuting distance for higher income. In rural areas, where appropriate jobs are rare, commuting longer distances into economic centers seems to prohibit a positive income effect. The results suggest that the positive income effect on commuting, which is found in other studies, does not exist for everyone and heavily depends on the residential location. Surprisingly, macro indicators on the local labor market context do not change the effects we found. This may be due to the fact that so far it is impossible to directly measure job opportunities on a county level. However, making assumptions on commutes must consider both, labor market structure and place of residence, and should take into account the differential starting positions of employees, ranging from urban to rural areas.

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## Appendix

		Target region			
		Urban district	Wider urban area	High density rural area	Low density rural area
Starting region	Urban district	882 (84.27)	143 (13.62)	20 (1.90)	5 (0.48)
	Wider urban area	450 (27.95)	1,123 (69.75)	26 (1.61)	11 (0.68)
	High density rural area	105 (26.18)	51 (12.72)	231 (57.61)	14 (3.49)
	Low density rural area	25 (6.72)	16 (4.30)	5 (1.34)	326 (87.63)
Overall		1.462 (42.59)	1.333 (38.83)	282 (8.21)	356 (10.37)

Table 4 Commuting combinations by regional type