Return to commuting in Sweden[*]

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Abstract

The main aim of this paper is to estimate the magnitude of the return to commuting and compare the relative returns received by men and woman. We apply fixed effect models to deal with individual heterogeneity that could potentially generate an endogeneity issue. A large dataset based on administrative registers is used for the analysis. Analysis are split by gender characteristics in order to capture significant differences in labor commuting patterns of both genders. Results indicate that individuals receive relatively small compensations per commuting distance with higher returns in agglomerations. Moreover, the relative return as a fraction of hourly wage is approximately similar for both genders. From a policy prospective, these results assign a monetary value received by individuals for commuting. In addition it provides evidences of similar bargaining powers for both genders.

Keywords: Earnings; Commuting; Return to commuting; Labor Mobility; Gender equality

JEL classification: J32, J61, R41

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1. Introduction

Commuting distances significantly increased during the last decades owing to the decrease of transportation costs, facilitation of accessibility to remote areas and improvements in infrastructures. Evidence from Western European countries suggests a relatively significant increase in commuting flows on daily and weekly basis (Sultana & Weber, 2007; Llyons & Chatterjee, 2007). The importance of matching demand and supply, and of ensuring the equilibrium in local labor markets in the context of sustainable development is recognized by policymakers of many European countries including Sweden. Sweden is not a peculiar country in this respect. The main aim of Swedish Transport Policy Act of 2009, for instance, was to provide sustainable and efficient transport provision for population and industrial production in the whole country (Swedish Government, 2008; Sandow & Westin, 2010). In Sweden, major investments were made in the infrastructure with the aim of increasing commuting streams between regions (Nutek, 2000; 2001).

From the political point of view, commuting is considered to be a solution to many issues generated by geographically separated labor markets such as mismatch between demand and supply within labor markets. The increase in both internal and external mobility flows might "grease wheels" for regional economies and speed up convergence between regions. Moreover, commuting mitigates earnings disparities and improves equality patterns between regions (Lundholm 2010; Nutek, 2000; Hazans, 2004). From the individual perspective, costs of commuting can be compensated by better carrier opportunities, increase in labour income or differences in terms of prices and amenities in the housing market (Renkow & Hower, 2000; Shuai 2012). Commuters may enjoy the advantages of better amenities where they live and higher wage in urban centers where they work (Fu & Ross 2007; Hover & Renkow 2000). Although commuting is seen as a solution to a variety of regional labor markets problems, it could also have negative consequences such as: the decrease of individual productivity due to absenteeism and psychological stress caused by commuting, the increase of traffic congestion, negative effects on environment and the social life of individuals (e.g., owing to reduced leisure time). Commuting also reinforces traditional family relationships (male breadwinner model) due to predominantly male commuting over longer

distances. This, in turn, leads to the reinforcement of gender inequality within the household. Sandow (2012) predicts, for instance, the increase of the probability of divorce for long-distance commuters. Lingren et al. (2014) find evidence of positive effects of commuting experiences on mortality.

The current literature provides two main reasons which might explain positive returns to commuting. The first maintains that firms possess some monopsony power over workers. This, in turn, allows employers to compensate commuting expenses incurred by workers (under competitive labor markets, workers are not compensated for commuting and wage levels are equivalent to the marginal product.) Therefore workers are able to re-negotiate wages with the employer for the fraction of commuting expenses in bilateral bargaining. An alternative theory suggests that employers might have different marginal productivity due to sectoral differences or agglomeration effects of urban centers.

In this study, we examine the role of commuting distance on individual earnings. We tested both hypotheses of re-bargaining the fraction of commuting costs applying an approach pioneered by Gutiérrez-i-Puigarnau & van Ommeren (2010) and Mulalic & Pilegaard (2010), and differences in the productivity of employees due to the agglomeration effects presented by Ross & Fu (2010). Taking into account significant differences in gender commuting patterns, we stratified our analysis by gender. A significant part of previous studies (Mulalic & Pilegaard, 2010; Ruppert, Stancanelli & Wasmer, 2012; van Ommeren & Gutiérrez-i-Puigarnau, 2011), suggests concavity of the wage-commuting profile, i.e. earnings increase with commuting distance at a decreasing rate. We have experimented with different samples within economically reasonable rage of distances in the Euclidian space, and have found a confirmation of this fact in our data. Moreover, the fixed effects estimation, applied in our analysis addresses the individual heterogeneity that poses a problem of endogeneity.

This study contributes to the existing literature in the several ways. Firstly, we analyze a significantly richer register-based longitudinal dataset. Mulalic & Pilegaard, (2010) and Gutiérrez-i-Puigarnau & van Ommeren, (2010) focus their analyses on employer-level data. At the same time, Manning (2003) and Stancanelli, Wasmer & Rupert, (2012) base their analyses on survey data. Another feature, that makes our analysis different, is the way of dealing with endogeneity. Mulalic & Pilegaard(2010) and Gutiérrez-i-Puigarnau & van Ommeren, (2010) conduct their

analysis in a setting of exogenous reallocation of employers and measure the compensating return for the related difference in commuting distances. The other approach (Manning 2003) is to analyze the association between commuting time and hourly wage considering commuting time being exogenous. Finally, some studies apply econometric methodologies requiring the availability of an instrument for commuting (Ruppert et al. 2012; Oswald 1999). We ground our analysis on the assumption that the main source of endogeneity is individual time invariant heterogeneity that affects simultaneously commuting and earning behavior. On one side individuals with higher ability may have faster growing career or higher bargaining power that would allow them to re-bargain higher fraction of commuting expenses. In the same time, workers with lower level of ability will have higher net commuting expenses, leading to acceptance jobs over shorter commuting distance. Hence commuting distance and earning should be positively correlated. Support for it was previously reported by the study of Ruppert et al. (2012). Under this identifying assumption, we obtain consistent estimates for the return to commuting by applying the fixed effects estimation procedure.

The structure of the paper is as follows. The next section provides an overview of the existing literature in the field of commuting, and the description of commuting patterns and the wage formation mechanism in Sweden. The description of the econometric model is presented in Section 3. Section 4 contains data and selection criteria behind our main sample, analyzed in this paper. Sections 5 and 6 report the main results from regression analysis of the male and female samples together with a comparison with the findings of previous studies. Section 7 denotes the results of estimating the wage growth model. The comparison between commuting patterns of males and females is described in Section 8. The conclusions are laid out in the Section 9.

2. Literature review: Commuting patterns and the consequences of commuting

There is a broad variety of theoretical and empirical studies that attempt to explain the positive return to commuting, and its causes and consequences. In this section, we briefly review the main papers which analyzed both theoretically and empirically these patterns, and the determinants and consequences of commuting.

2.1 Determinants and patterns of commuting

The importance of the spatial dimension of the labor market was recognized long time ago by Simpson (1980, 1992), Rouwendal & Rietveld (1994) and van Ommeren et al. (2000), among others. The main approach was to view commuting as the result of individuals' optimizing behavior during the job search process in spatial labor markets. This approach was pioneered and developed by Rouwendahl (1998; 2004) who suggested the existence of equilibrium in the labor market with spatial characteristics. The model also attempted to explain such phenomenon as "excess commuting"[3] which was considered as a significant issue in studies of commuting. Moreover, the model presented by Rouwendal (2004) suggested the existence of critical values for the maximally acceptable daily commuting distances for individuals. This approach was further developed by van Ommeren et al. (2000) in the context of job and residence choices, since the authors suggested these choices to be simultaneous. They concluded that factors that cause imperfections in the housing market have an ambiguous impact on the job-search process. In a similar fashion, Wasmer & Zenou (2002, 2006) developed a urban equilibrium where individuals work and reside in different locations, with employed and unemployed people perfectly segregated. Moreover, they introduced a land market which in turn leads to positive costs of reallocation. This allows them to demonstrate the existence of the zones in the city where employed and unemployed labor coexist. Further on, Rupert & Wasmer (2009) suggested that with high commuting costs, high frictions in the residential market play an important role in the decline of individual mobility. Together with that, Manning (2003) proved that commuting appears to be a

[3] The concept of "excess commuting" describes the difference between the actual commuting and equilibrium commuting within a monocentric urban model.

result of the "virtually existing" monopsony power of employers that affects job search through the spatial dimension. Along with all the above mentioned theoretical studies that developed the self-selection mechanism into commuting, it is worth mentioning the studies that are theoretical in nature, although contributing significantly to shaping the empirical analysis. Van Ommeren (2004) analyzed the commuting distribution. He showed the heterogeneity of vacancies or job search with the spatial component under the labor market rigidities. Moreover, this study suggested that the residential mobility does not contribute to explaining the shape of commuting distribution. The final important conclusion of his work is that the shape of commuting density function is similar for countries with different spatial structures.

While theoretical studies provide clear background theory for the selection mechanism, empirical studies have suggested ambiguous results. The analysis carried out by Rouwendahl (1999) showed the importance of the spatial component during job search suggesting the fact that around 50 % of jobs originate from the nearest 25 kilometers area. The existence of such a boundary distance was further investigated by Lundholm (2010) who suggested the idea of "narrow labor markets" – the labor market with commuting distances that have an impact on daily life of individuals but that is tolerable for most of them. Furthermore, the concept of "extensive labor markets" was also developed, which are related to labor markets with commuting distances entailing pecuniary and non-pecuniary costs unacceptable for some individuals but still tolerable for others. Eliasson et al. (2003) found clear evidences of the significant impact of the labor market characteristics of surrounding areas on labor mobility, although without clear answers to the question of the impact of the characteristics of surrounding labor markets on commuting decision. In addition, the study conducted by Sandow (2008) focused particularly on the various impacts of commuting in the "extensive labor market" using the administrative longitudinal data for northern Sweden where this issue is particularly relevant due to low population density and high commuting distances. Among other findings, the author showed that the commuting patterns of the population are significantly affected by the geographical structure. Moreover, clear evidences of the significant gender differences in commuting patterns was also provided.

2.2 Determinants of commuting

There exist some stylized facts about employees' commuting patterns. One being that the commuting distance decreases with age and experience (van Ham et al. 2001). The previous studies, such as Booth (2009), showed that young people are more prone to commute than older people. The explanation could be that older people obtain more firm-specific human capital, and the subsequent return from job-to-job changes is lower than for younger people. Since the previous studies revealed substantial fixed costs of commuting, the expenses induced by long-distance commuting could be unacceptably high for them. On the other hand, older people have more experience than younger colleagues in the same educational category, so they have more career opportunities and, as a result, higher return from commuting. Due to the fact that commuting becomes more costly with age, more skilled employees are able to commute due to higher earnings (Osth, 2007). It is reasonable to assume that there is an age threshold for commuting. Before achieving this threshold age, commuting increases but after passing the threshold, commuting decreases. It is shown by Dargay & Clark (2012) that the length of commuting distance is reasonably affected by the population density in the particular region of residence. Therefore people who live in rural areas travel more than those who live in metropolitan areas. This is likely to be related to the lack of employment opportunities in the place of residence. Therefore, these areas are characterized by relatively lower population density and higher unemployment rate. Another important factor affecting commuting intensity is the concentration of firms and enterprises in a region. Ham et al. (2001) proved that the accessibility of employment is an important characteristic which affects the probability of job acceptance over a greater distance. The effect of education on commuting distance is unambiguous. Previous studies such as Bartel and Lichtenberg (1987) argued that more educated people have a faster developing career and, as a result, are willing to commute more. Borsch-Supan (1990) supported this finding by explaining it with the decreasing effect of transaction costs. Since higher education is assumed to lead to higher returns, the fixed commuting cost will be lower at the margin for individuals with higher return. Better-educated individuals are able to carry the job-search process more efficiently, probably due to their job-searching skills and network obtained during the years of education. It is also worth mentioning that jobs requiring higher education are often more specialized and less spatially dispersed than those that require a lower qualification. Gender is an important

determinant in the choice of commuting distance. It is a stylized fact that women on average commute less than men. Young single women approximately accept the same commuting distance as single men. The evidence proposed by van Ham et al. (2001) shows that, a highly educated unmarried woman has a higher probability of accepting jobs over a greater distance than men with the same characteristics. The age effect has a more significant impact on the probability of being a long-distance commuter for women. Having a partner who works has no effect on the commuting distance for men, however decreases this distance for women. The explanation of this result could be an additional workload on the woman in household production and supports the theory of "traditional family" with one working spouse. As expected, the presence of children has an impact on both partners by making them less spatially mobile than single or unmarried people. The likelihood of commuting for a long distance is negatively related to the number of children in the family (McQuaid & Chen 2012). Contrary to all these findings, Carmsta (2005) showed that gender effects are almost absent for the "modern groups"[4] of the population. The sector of employment has also an important effect on commuting distances. Workers employed in the financial, business, and construction sectors commute more than those who are employed in health care or education sectors (van Ham et al. 2001). This can be explained by the fact that jobs in the financial, industrial, and banking sectors are relatively spatially concentrated, while vacancies in social services are more evenly geographically dispersed. Another important factor which increases the probability of commuting for a long distance is the effectiveness of transportation.

2.3 Consequences of commuting

van Ommeren (2002) focused on the consequences of commuting applying the equilibrium job-searching model. The author demonstrated that in the presence of imperfections such as searching costs and bargaining between employers and workers, the presence of market power dictates the extent to which workers can be compensated for commuting. Yet, a surprising evidence was that the workers with stronger market power are compensated less than workers with weaker market power. This stream of research found further development in the study of van Ommeren & Rietveld

[4]Groups with characteristics attributed to the "modern lifestyle" such as late marriage or high mobility

(2005) of the "commuting time paradox". The authors suggested that under the conditions of constant labor market tightness, the ratio between commuting expenses (pecuniary and non-pecuniary) and wages remains constant over time. It is explained, on the one side, by the increase in productivity in the long run that leads to the increase in wages, and that leads, on the other side, to the shift of the preferences in the transportation mode. The shift in preferences leads to a decrease in non-pecuniary costs but to a rise of pecuniary costs (for example individuals can choose faster but more expensive transport modes such as fast trains or private cars instead of ordinary public transport).

Many studies are focused on the consequences of commuting on various socio-economic aspects. Rouwendahl (1999) estimated the willingness to accept a lower wage of 0.12 Gulden in order to avoid an additional kilometer of commuting for the Netherlands. Further on, Manning (2003) suggested that workers are not fully compensated for long-distance commuting. Moreover, it was found that the job separation rate for commuters is higher than for stayers. The evaluation of the compensation for commuting was further developed by Fu & Ross (2010) who showed clear agglomeration effects for the wages of commuters. Ruppert, Stancanelli & Wasmer (2012) reported the significant impact of commuting time as vacancy characteristics on job-acceptance decisions and future wages rates. The authors documented an evidence of wage increasing with distance at decreasing rates. Mulalic & Pilegaard, (2010) estimated the bargaining power of employees through the estimation of wage increases owing to long-distance commuting in case of exogenous firm reallocation. They suggested that individuals are able to re-bargain ex-post around 0.5% of the salary for every kilometer increase in commuting distance. Van Ommeren & Fosgerau, (2009) analyzed the workers' daily marginal cost of commuting and suggested it to be about 17 Euro per hour of commuting. Gutiérrez-i-Puigarnau & van Ommeren, (2010) suggested that commuting increases the daily and weekly labor supply of individuals, whereas the subsequent study (van Ommeren & Gutiérrez-i-Puigarnau, 2011) demonstrated that commuting positively affects the rate of absenteeism and job separation of individuals. It is also worth mentioning the study of Hazans, (2004) who showed in his analysis that commuting decreases the regional urban-rural wage and employment disparities between the capital city and surrounding regions, and positively affects national output.

2.4 Commuting in Sweden

Previous studies conducted in the field of labor mobility in Sweden such as Lundholm, (2010) Sandow & Westin (2010) and Sandow (2008) suggests that 50% of men commute less than 8 kilometers to their job whereas 50% of women commute for less than 6 kilometers. Such a difference in commuting distances can be explained by many factors: such as the role of women in household production, individual heterogeneity towards commuting or the different industry chosen by individuals. Male are employed in the construction, manufacturing and retail sectors, while women mainly work in private and public services.

Results from the previous studies carried by Lundholm, (2010) and Sandow (2008) suggest that commuters receive significantly lower income in comparison to stayers in the male and female subsamples of the population. Male, commuters over 30 kilometers earn 2300 hundreds of annual income (approximately 25555 EUR) compared to 3,369 hundreds for stayers (37,433 EUR). The difference in earnings between commuters in the female population is even stronger: 1,351 hundred SEK (15,011 EUR) for commuters and 2,492 hundred SEK for stayers (26,263 EUR). Therefore, the return to commuting becomes ambiguous in comparison with the predictions of theoretical models, at least when considering the raw data.

All above mentioned studies give a clear theoretical framework and allows us to proceed further in our empirical analysis.

3. Description of the econometric model

This section contains the description of our empirical model together with the motivations behinds our choices. The formal identification strategy will be presented later on in Section 4.

In this analysis, the relationship between *annual earnings* as a dependent variable and the distance of commuting as an independent variable, including a set of various socio-economic and geographic variables is studied through the application of the fixed effect model. In our setting, fixed effect estimation allows us to estimate models with longitudinal data accounting for individual heterogeneity, addressing potential endogeneity issues (individual self-selection into commuting) generated by time-invariant unobservable characteristics. Previous studies suggest, indeed, that there might be unobserved individual time invariant features influencing simultaneously commuting distance and individual earnings (Ruppert et al., 2012; Mulalic & Pilegaard, 2010). . Our analysis is carried out on a 7-year longitudinal panel dataset using Ordinary Least Squares (OLS) and Fixed Effect (FE) estimation. It has borrowed some features from the previous studies conducted by Manning, (2003), Mulalic & Pilegaard, (2010) and Ruppert, Stancanelli & Wasmer (2012) together with the set-up and selection of variables made for Sweden by Eliasson, Lindgren, & Westerlund, (2003), Lundholm, (2010); Nakosteen, Westerlund, & Zimmer, (2008), Sandow & Westin, (2010).

Taking into account the underlying theory and the results of analysis of the descriptive statistics, the model for estimation of effect of commuting distance on annual earnings takes the form:

$$lnLoneInk0_{it} = \alpha_{it} + \gamma_1 dist_{it} + \gamma_2 squaredist_{it} + \beta_1 X_{it} + z_i + \varepsilon_{it} \quad (1)$$

where $i=1 \ldots T$ stands for cross-section units (individuals) and $t=1 \ldots K$ indicates time, whereas α, γ and β are coefficients to be estimated and X is a generic vector of additional explanatory variables that captures individuals' lifecycle events and labor market conditions at the place of work. The list of variables and their definition is presented in Table 1.

The main dependent variable *lnLoneInk0* indicates the annual earnings that individuals received from employment in natural logarithms. Since the main assumption of the model is that individuals should work full time, *lnLoneInk0* was considered in the interval 1,500 hundreds SEK and 8,518 hundreds SEK of gross annual income. The rationale behind imposing the lower threshold, which constitutes the lowest quartile of the earnings distribution, is explained by the need to eliminate the bias generated by the inclusion of part-time employment. Individuals with part-time employment might possess more spare time for commuting. The introduction of the upper bound is explained by the exclusion of individuals who are more likely to work overtime (Isacsson & Swärdh, 2007).

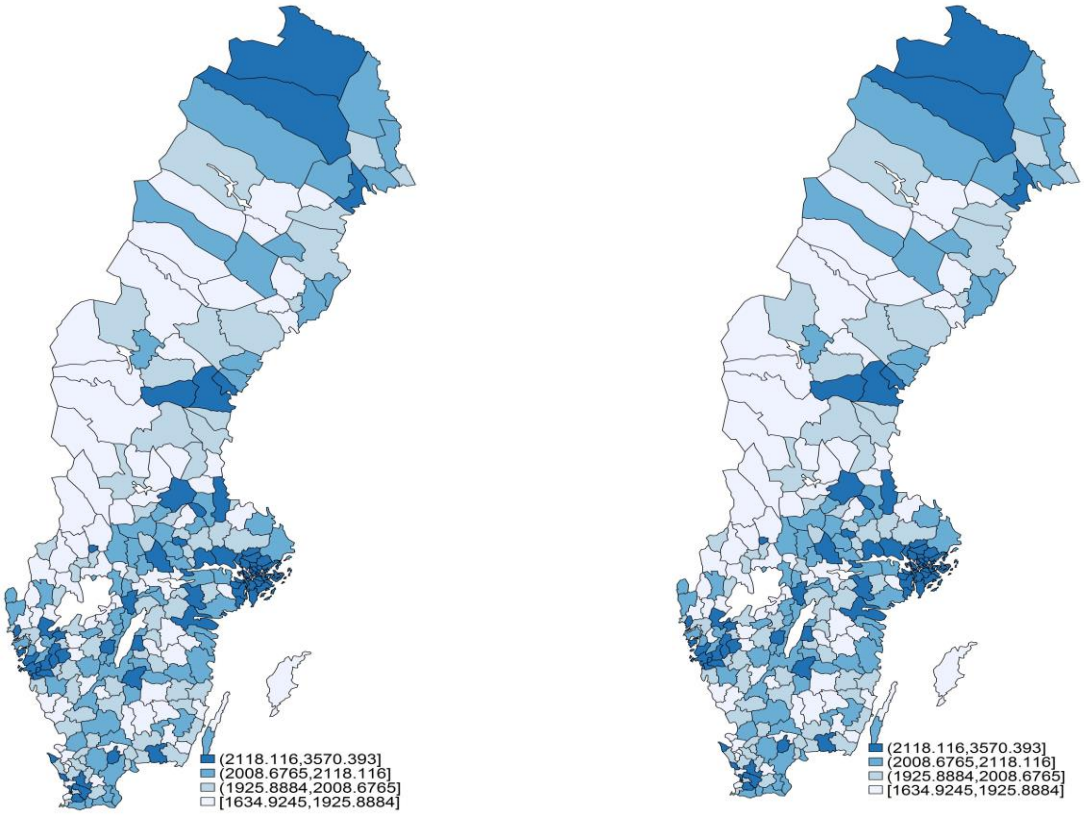

Figure1. Average earnings by municipality in Sweden. Male and female samples

The spatial distribution of average annual earnings in the male and female samples is presented in Figure 1. The municipalities with lowest earnings are concentrated in the middle and west part of the country. At the same time the highest earnings are shown in the three biggest urban

agglomerations: Goteborg, Stockholm and Malmo, and in municipalities along the coastal line. The county of Norrbotten also shows high earnings. It can be viewed as an outlier due to the significant fraction of people employed in the extractive industry.

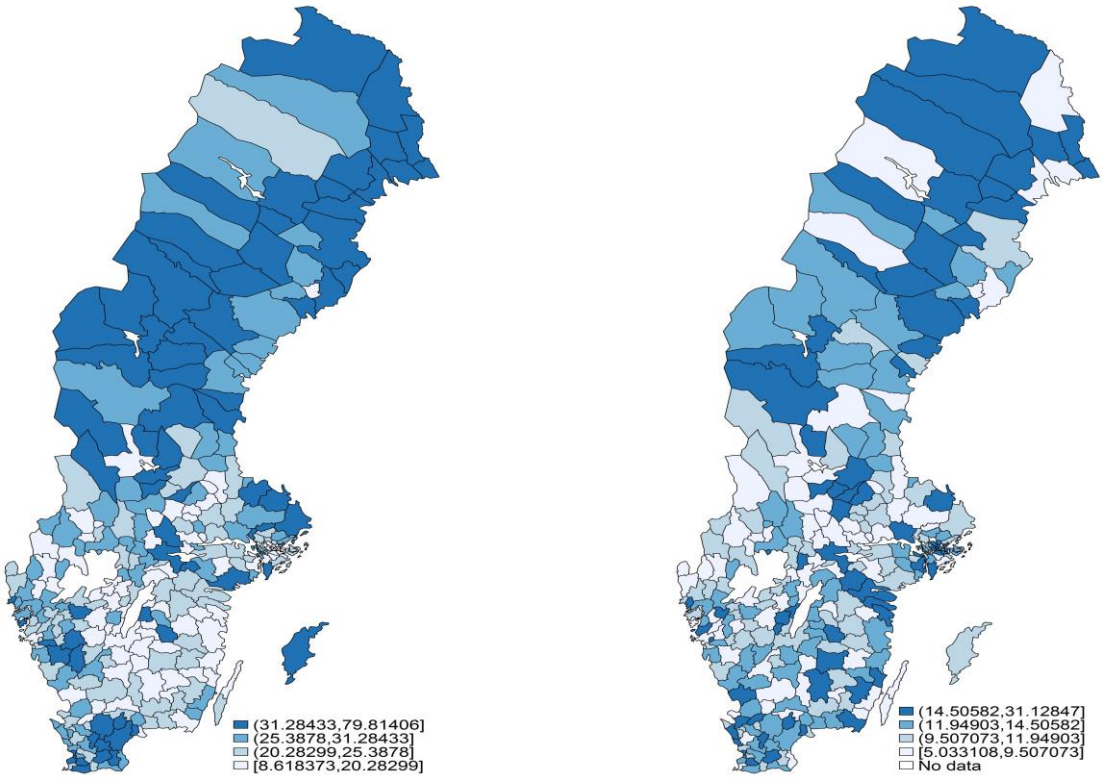

Figure 2. Average commuting distances by municipality in Sweden. Male and female samples

$Dist_i$ is commuting distance in kilometers for every individual calculated using Pythagoras formula. A unique future of our dataset is the availability of geographical coordinates on individuals' place of residence and place of work on 100 meters span. Therefore, we are able to calculate a very good proxy of the daily commuting distance of individuals. The main assumption behind this variable is that the individuals commute on a daily basis. Moreover individuals' place of residence should be geographically separated from their place of work. Therefore, individuals who work at home are excluded from our analysis.

The variable $squaredist_i$ specifies the square of commuting distance covered by individuals on a daily basis. The inclusion of the squared form of commuting distance is justified by the possible

non-linearity in the relationship between earnings and distance as it is suggested by both theory (Lundholm 2010) and descriptive statistics. In particular Figure 3 represents median-band plot of annual income against commuting distances. The possible concavity can be traced from the graph especially for the female sample.

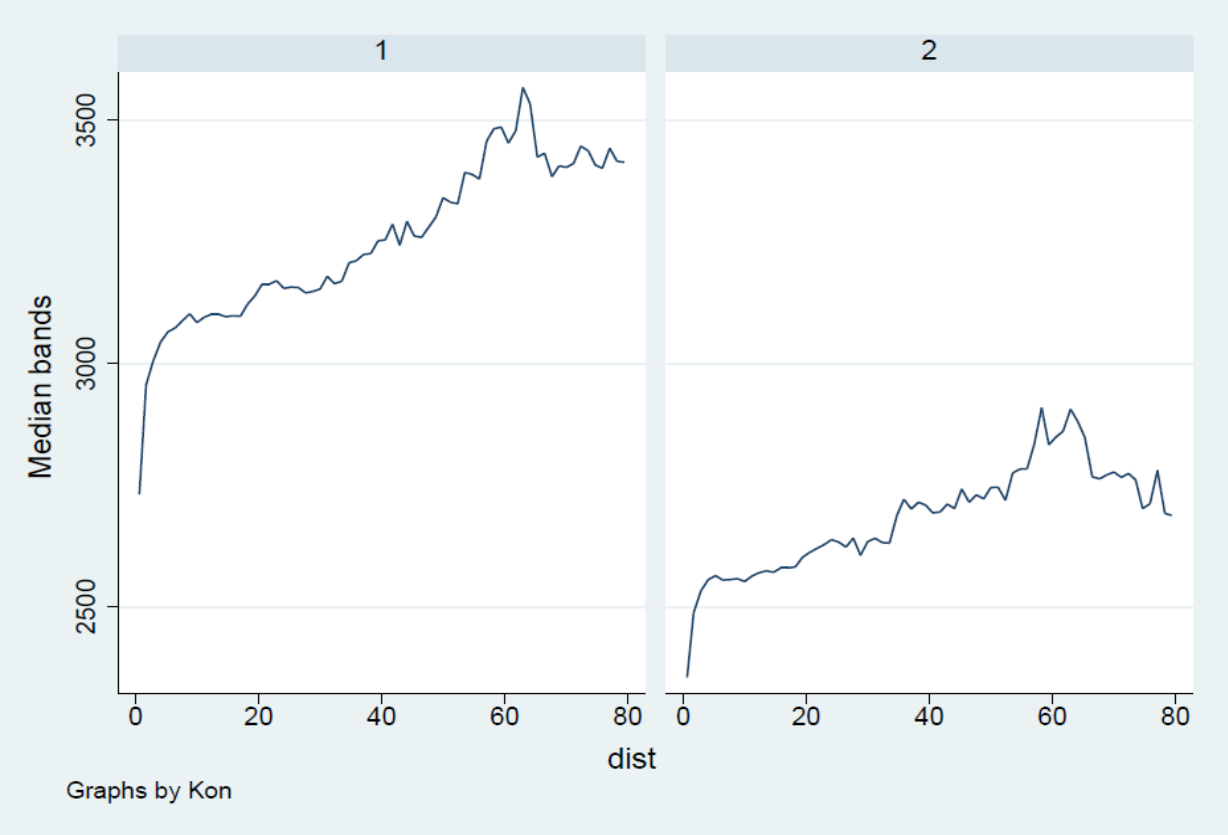

Figure 3. Cross-plot of earning against commuting distance

Since the return for commuting distance in the fixed effect setting is identified only for those individuals who changed the commuting distance over the length of study period, the variation in commuting distance and adequacy of control will be discussed in more details. As unemployed people are omitted from the analysis, the main source of variation in commuting distance is explained by the on-the-job mobility. It worth to distinguish between voluntary and involuntary change of labor market status. The voluntary change of the labor market status is associated with future increase in return to experience, the involuntary change is related to decrease of earnings or losing the place of employment. In both cases the significant role is devoted to the individual time

invariant heterogeneity e.g.: mathematical performance or manual skills. The unobserved ability can affect spatial labor mobility in both directions: on one side' individuals with higher ability may have faster growing career associated with the spatial mobility; one the other side workers with lower ability can be affected by the hidden or explicit unemployment. The elimination of ability bias may be addressed through application of the fixed effects estimation approach (Manning, 2013;Winter-Ebmer & Zweimuller, 1999; Adowd et al., 1999 Winter-Ebmer, 1996) .

The variables *famstf01, famstf02, famstf03* and *famstf04* control for the marital status of individuals. The variable *famstf01* is a dummy variable that denotes the presence of wife or husband. The *famstf02* is dummy controlling for presence of "sambo"[5]. *Famstf03* is a dummy variable for being a single mother or a single father. *famstf04* indicates single individuals. The reference category was selected to be individuals who are single. Previous studies suggest that the presence of a partner and/or children should have a significant impact on the decision to commute. It is explained by individuals accepting job offers at the household level rather that individually (i.e., collective household model). Moreover, this effect might alter the commuting distance for females due to additional tasks in household production.

Table 1. Definition of variables

Variable	Description
lnLoneInk0	Annual income for employed individuals in log form
dist	Round commuting distance in kilometers calculated using the Pythagoras formula (individuals who do work at home or commute over the border of extensive labor market are excluded from the analysis)
squaredist	Square of the commuting distance
famstf01	Dummy variable for marriage status of individuals
famstf02	Dummy variable for the civil cohabiting status of individuals
famstf03	Dummy variable for single father/mother
famstf04	Dummy variable for single individuals (Reference category)
ed01	Dummy variable for level of education corresponding to pre-gymnasium level of education (Reference category)
ed02	Dummy variable the gymnasium level of education (Reference category)
ed03	Dummy variable for the post-gymnasium level of education (less than 2 years)
ed04	Dummy variable for post-gymnasium level of education (more than 2 years)
ed05	Dummy variable for university education
ed06	Dummy variable for post-graduate education
25.cutage0	Dummy variable indicating individuals in the age of 20 −25 (Reference category)
30.cutage0	Dummy variable indicating individuals in the age of 25 −30

[5] "Sambo" is civil cohabitation status. It is now as common as marriage.

Table 1 (continued)

Variable	Description
35.cutage0	Dummy variable indicating individuals in the age of 30 −35
40.cutage0	Dummy variable indicating individuals in the age of 35 −40
45.cutage0	Dummy variable indicating individuals in the age of 45 −50
50.cutage0	Dummy variable indicating individuals in the age of 50 −55
puserv0	Indicator for the employment in the public sector (Reference category)
manuf0	Indicator for the employment in manufacturing sector
constr0	Indicator for the employment in the construction sector
retail0	Indicator for the employment in the retailing
prserv0	Indicator for the employment in the private service
lnMedwage0	Logarithm of the median of wage prevailing at the labor market
Unemplrate0	Unemployment rate at the Labor Market of individual's origin
sizew0	Employment at the labor market of individual's origin

Notes: Apart from the presented variable, there were included a set of dummies for the time periods

The variables *ed01, ed02, ed03, ed04, ed05 and ed06* are dummy variables that specify the educational attainments of the individual. The lowest level is *ed01* which corresponds to the pre-gymnasium level of education, whereas the highest one--*ed06* corresponds to the possession of the PhD or Licentiate degree[6]. The reference category was selected to be *ed01* or *ed02 (*jointly) which is equivalent to completion of high school. The previous studies suggest that education has a significantly positive impact both on earnings and mobility.

In order to capture the age profile of commuting, a set of dummy variables for intervals was introduced into the model. The dummies for age intervals allow capturing the concavity of the age profile as a proxy for experience. The set of controls for the sectors of employment are $puserv0_i$, $manuf0_i$, $constr0_i$, $retai0l_i$ and $prserv0_i$, where $puserv0_i$, stands for the employment of individuals in public service, *manuf0* in manufacturing, *constr0* in construction, *retai0* in retailing and in the private service sector. The public sector category was selected as the reference group due to the highest spatial dispersion of this sector.

Apart from that, a set of local labor market characteristics was included in the estimation such as: logarithm of the median of wages prevailing at the local labor markets (*lnMedwage0),* the unemployment rate prevailing in the labor market (*Unemplrate0),* and the number of employed

[6] In Sweden, Licentiate degree is a pre-doctoral degree which requires completion of all courses and academic research equivalent to half dissertation.

people at the local labor market (*sizew0).* A set year dummies was included into the analysis in order to capture the effect of business cycles over the estimated period.[7]

[7] Apart from that, a specification also including a set of labor market dummies was also estimated. We do not report these results since the introduction of labor market fixed effects did not produce any relevant change in the coefficients on commuting distances (linear and squared).

4. Data description and sample selection

This section contains a data description together with the criteria and the motivation for the selection of the particular estimation sample.

4.1 Description of the data

The data used in the analysis is collected from the administrative registers of Labor Market Board (HANDEL) and Statistics Sweden (LOUISE). LOUISE provides information about family conditions, presence of children, education, employment status, sector of employment, branch of employment together with geographical coordinates for the place of residence and the place of work. Data from Labor Market Board reflects information for income from employment and non-employment activities. The merged dataset is a longitudinal geocoded panel that contains information about all individuals in the age range 20-64 living in Sweden for the time period 2003—2009. The analysis is carried out at the individual level. The presence of exact coordinates of the places of work and residence in the UTM (United Transverses Mercator) system allows defining the commuting distance using the Pythagoras formula. The advantage of this system lies in the simplification of the calculation of the commuting distance. On the other side, it is the shortest geographical distance between place of work and residence without taking into account the nonlinearity in the construction of the road system. Nevertheless, the distance calculated in this fashion can be considered as a good proxy for actual distance of commuting and, therefore, commuting expenses. The analysis focuses on the individuals who are in the age between 20 and 60 and are employed. One potential source of bias arises from the fact that individuals who experience difficulties in finding a job in the narrow labor market might shift to the extensive labor market[8] during the job-search process during the year. This leads to the systematic misreporting of annual income and subsequent underestimation of the role of the commuting distance in the wage formation due to the possibility of working less than full time, and therefore the availability

[8] Narrow labor market—the labor market with commuting distances impacting daily life of individuals but tolerable for the most of them (0-30 km). Extensive labor market—the labor market with commuting distances that entail pecuniary and non-pecuniary losses unacceptable for most individuals (30- 120 km).

of additional time for commuting. To eliminate this issue, individuals who possessed alternative sources of income from the welfare system such as unemployment benefits were excluded from the analysis. Together with that, individuals who carry entrepreneurship activities were not taken into account in our analysis. The motivation behind this exclusion lies in the fact that entrepreneurs have places of work rather than jobs and income that is independent of commuting distance (van Ommeren & van der Straaten 2008). Moreover, the commuting distance was constrained to the maximum border of the extensive labor market which is 120 kilometers of one way distance as proposed by Lundholm, (2010). This distance can be approximated to 3.5 hours of commuting taking into account road complexity and traffic congestion. This sample cut allows excluding individuals who commute on a weekly basis. The analysis was constrained to those individuals who have both coordinates of the place of residence and of the place of work. One of the main assumptions of the analysis is the observability of commuting distance. Also, individuals employed at home are very different in their characteristics. Therefore, those individuals who work at home were excluded from the analysis. Moreover, we further imposed an assumption about the existence of an economically meaningful distance for commuting i.e. individuals should incur pecuniary and/or non-pecuniary losses. That is why the individuals with commuting distances less than 500 meters one way are excluded from the sample as well. Together with the information on earnings and commuting distance the dataset contains information about the age, gender, sector of employment, education, marital status, and presence of children and characteristics of the labor market of residence such as: unemployment rate, employment and median of wage prevailing at the local labor market. The sample is split by gender. The motivation behind lies in the different commuting patterns for males and females together with the difficulties experienced by females in finding jobs, and family constrains on the long distance commuting. Although we ran the analysis by the gender, labor market variables were calculated for the whole sample (pooled genders) with the purpose of capturing mutual substitution of male and female workers in the labor market.

4.2 Description of variables

The variables of main interest are individual gross annual labor income *LoneInk0* and commuting distance *distance0*. Income variable *LoneInk0* was transformed nto the log form whereas distance variables represent linear term *dist* and *squareddist* introduced in order to capture the nonlinearities in of distance profile in the model. The descriptive statistics suggests that the average earning of males is 3,691 hundreds SEK (40,079 EUR) while the annual earning of females is 3.82 hundreds SEK (33,468 EUR).

Table 2. Descriptive statistics of the male sample

Variable	Obs	Mean	Std. Dev	Min	Max
lnLoneInk0	*2862864*	*7.9601*	*0.3626*	*7.4237*	*9.0543*
dist	*2862864*	*28.2963*	*35.5864*	*1.0198*	*239.99*
squaredist	*2862864*	*20.6707*	*56.8389*	*0.0104*	*576.9828*
famstf01	*2862864*	*0.4990*	*0.4999*	*0*	*1*
famstf02	*2862864*	*0.0314*	*0.1745*	*0*	*1*
famstf03	*2862864*	*0.0468*	*0.2112*	*0*	*1*
nat	*2862864*	*0.0890*	*0.2848*	*0*	*1*
ed03	*2862864*	*0.4860*	*0.4998*	*0*	*1*
ed04	*2862864*	*0.0808*	*0.2754*	*0*	*1*
ed05	*2862864*	*0.2621*	*0.4398*	*0*	*1*
ed06	*2862864*	*0.2053*	*0.1418*	*0*	*1*
30.cutage0	*2862864*	0.0985	*0.2980*	*0*	*1*
35.cutage0	*2862864*	0.1028	*0.3715*	*0*	*1*
40.cutage0	*2862864*	0.1428	*0.3499*	*0*	*1*
45.cutage0	*2862864*	0.1723	*0.3777*	*0*	*1*
50.cutage0	*2862864*	0.1874	*0.3902*	*0*	*1*
55.cutage0	*2862864*	0.1893	*0.3917*	*0*	*1*
manuf0	*2862864*	*0.2788*	*0.4484*	*0*	*1*
constr0	*2862864*	*0.1054*	*0.3071*	*0*	*1*
retail0	*2862864*	*0.2012*	*0.4009*	*0*	*1*
prserv0	*2862864*	*0.0989*	*0.2986*	*0*	*1*
lnMedwage0	*2862864*	*7.4763*	*0.3540*	*5.3602*	*7.9412*
Unemplrate0	*2862864*	*0.1515*	*.0520*	*0.02*	*0.4952*
sizew0	*2862864*	*307947.4*	*297732.9*	*790*	*785363*

The main control variable distance0 was transformed into kilometers. The descriptive statistics suggest that the average commuting distance for the commuters within the narrow and extensive labor market is 28 kilometers for males and 22 kilometers for females. Together with that, 50 % of the male population commutes within 6.53 kilometers and 50 % of females for 4.85 kilometers. This result suggests that males and females are employed in positions that require different levels

of commuting. Alternatively, assuming different spatial dispersion of industries across the city, it can be an evidence of the self-selection or gender segregation by sector. The higher percentage of males employed in manufacturing supports this hypothesis.

Together with that, the return to commuting is identifiable in the fixed effect setting only for those individuals who have changed the distance to workplace. Therefore Table 3 and Table 4 demonstrates the numbers of individuals who experienced change in the commuting distance over the study period by gender.

Table 3. Number of switchers by the type of exit. Male sample

Type of exit	*Residential stayers*	*Residential movers*
Individuals with no change in employer or workplace	*406290*	*362194*
Individuals who changed workplace (within same employer)	*167928*	*92856*
Individuals who changed employers and workplace	*357159*	*542851*

Table 3 and Table 4 describe a number of switchers[9] .i.e. the number of individuals who have changed either a place of work or a place of residence during study period. The figures in Tables 3 and 4 suggest that number of individuals with stable place of work and residence is about 20% of overall size of the panel. In the same time we observe significant number of people who have changed workplace within the same employer, changed employer and workplace and changed a place of residence. Therefore, the remaining number of switchers is sufficient for accurate calculation of effect of commuting on earning in the fixed effect setting.

The results from Table 3 and 4 indicate the higher number of residential movers among males. In the same time, women more often experience a move to the different workplace within the same employer which can be explained by the higher workplace attachment among females.

[9] The switcher is considered an individual if he/she at least one changed the place of work or residence. Workers employed at firms which were a subject of merging or change of holders are considered to be stayers if they had not moved to the other place of work.

Table 4. Number of switchers by the type of exit. Female sample

Type of exit	*Residential stayers*	*Residential movers*
Individuals with no change in employer or workplace	*443372*	*325546*
Individuals who changed workplace (within same employer)	*198452*	*103024*
Individuals who changed employers and workplace	*302935*	*419602*

Other facts which can be observed from the descriptive statistics are that on average there is a higher fraction of females with high education, but a higher percentage of males with PhD or Licentiate degree.

Table 5. Descriptive statistics of the female sample

Variable	Obs	Mean	Std. Dev	Min	Max
lnLoneInk0	*2008503*	*7.8524*	*0.3279*	*7.4237*	*9.0543*
dist	*2008503*	*22.0928*	*28.9074*	*1.0198*	*239.9921*
squaredist	*2008503*	*13.2373*	*41.8717*	*0.0104*	*575.962*
famstf01	*2008503*	*0.5338*	*0.4988*	*0*	*1*
famstf02	*2008503*	*0.0999*	*0.2928*	*0*	*1*
famstf03	*2008503*	*0.0181*	*0.1333*	*0*	*1*
nat	*2008503*	*0.1038*	*0.3050*	*0*	*1*
ed03	*2008503*	*04087*	*0.4916*	*0*	*1*
ed04	*2008503*	*0.0438*	*0.2048*	*0*	*1*
ed05	*2008503*	*0.4495*	*0.4974*	*0*	*1*
ed06	*2008503*	*0.0133*	*0.1145*	*0*	*1*
30.cutage0	*2008503*	0.0677	0.2513	0	1
35.cutage0	*2008503*	0.0744	0.2625	0	1
40.cutage0	*2008503*	0.1401	0.3470	0	1
45.cutage0	*2008503*	0.1985	0.3988	0	1
50.cutage0	*2008503*	0.2216	0.4153	0	1
55.cutage0	*2008503*	0.2147	0.4106	0	1
manuf0	*2008503*	*0.1038*	*0.3550*	*0*	*1*
constr0	*2008503*	*0.0156*	*0.1242*	*0*	*1*
retail0	*2008503*	*0.1318*	*0.3383*	*0*	*1*
prserv0	*2008503*	*0.0.775*	*0.2673*	*0*	*1*
lnMedwage0	*2008503*	*7.5037*	*0.3418*	*5.3690*	*7.9412*
Unemplrate0	*2008503*	*0.1534*	*0.0511*	*0.02*	*0.4955*
sizew0	*2008503*	*335310.1*	*304788.1*	*790*	*785363*

The comparison suggests that the fraction of single parents is higher for females. The main results from the descriptive statistics for both genders are presented in Table 2 (Male subsample) and Table 5 (Female subsample).

5. Analysis of the male sample

The estimated results from of the male sample are presented in Table 6. Our estimates document the concavity of the earnings profile with respect to commuting distance. Individuals receive an increasing return from commuting at a decreasing rate. The coefficient of the commuting distance derived with OLS is 0.000566 whereas the estimated coefficients of the squared term of the commuting distance divided by 100 is -0.0000129. It is worth mentioning that in this setting the squared term is insignificant.

Back of the envelope calculations, assuming one hour of commuting time to be approximately equal to 35 kilometers, and a hourly wage of 199 SEK (22.11 EUR) suggest that individuals receive a compensation of 31 SEK (3.44 EUR) per one hour of daily commuting[10], which constitutes 16 % of hourly wage.

The fixed effect (FE, hereafter) estimation suggests somewhat lower point estimates of distance (0.000305). At the same time, the coefficient of the quadratic term is much higher and more significant (-0.000156). It implies that individuals receive 17SEK (2 EUR) of reward for one hour of daily commuting. It is approximately 8.5% of the individual's hourly wage[11].

The age dummies in OLS and FE significantly affect earnings with a clear evidence of concavity with a turning point between 40 and 45 years. Earnings increase for the age groups up to 45 years, and show a decrease for older age categories.

Individuals experience 8.3% increase in their earnings if they are married when using OLS, and 1.6% increase using the FE estimation compared to the baseline category of single individuals. Living in cohabitation increases earnings by 4% with OLS and 0.3% with FE. One of the explanations of this phenomenon is a redistribution of family duties and economies of scale in household production that affect labor supply. Single fathers with children of age below 18 experience a wage penalty of 4.5% with OLS, and 3.1% with FE estimation. Indeed, the presence

[10] This proxy does not include the congestion effect. Moreover, it might significantly vary due to the differences in the place of location, development of local infrastructure and selection of transport mode.
[11] These results are likely to underestimate the real amount due to the business travels and absenteeism.

of young children might negatively affect labor supply patterns, which is reflected in annual earnings.

Table 6. Estimation results using OLS and FE. Male sample

Variables	*Male sample OLS estimation*		*Male sample Fixed effect estimation*	
	coefficient	*t-values*	*coefficient*	*t-values*
Distance variables				
Distance	*0.000566****	*29.53*	*0.000305****	*9.12*
Square distance/100	*-0.0000129*	*-0.77*	*-0.000156****	*-5.80*
Age variables				
Age between 25 and 30	*-0,0186****	*-17,58*	*0,10599****	*82,15*
Age between 30 and 35	*0.0126****	*11,65*	*0.1854****	*106,42*
Age between 35 and 40	*0.0525****	*49,08*	*0.2149****	*98,15*
Age between 40 and 45	*0.0717****	*68,79*	*0.2184****	*86,04*
Age between 45 and 50	*0.0736****	*71,35*	*0.2003****	*70,18*
Age between 50 and 55	*0.0727****	*70,57*	*0.1756****	*55,57*
Age between 55 and 60	*0,0767****	*74,21*	*0,1468****	*42,33*
Family status variables				
Married	*0.0838****	*178.98*	*0.0165****	*16.69*
Living in cohabitation	*0.0461****	*40.80*	*0.00363**	*2.45*
Single mother/father	*-0.0457****	*-41.67*	*-0.0318****	*-16.99*
Education level				
Gymnasium level of education	*0.0654****	*122.13*	*0.00293*	*0.39*
Post- gymnasium level of education <2 years	*0.218****	*253.34*	*0.0676****	*8.09*
Post-gymnasium level of education >2 years	*0.263****	*378.41*	*0.145****	*19.04*
University level of education	*0.423****	*237.20*	*0.221****	*25.65*
Nationality	*-0.0635****	*-86.30*	.	.
Sector of employment				
Manufacture	*0.0705****	*127.50*	*-0.00794****	*-5.50*
Construction	*0.0546****	*76.49*	*0.0217****	*11.63*
Retailing	*0.0480****	*75.96*	*0.000801*	*0.56*
Private services	*0.131****	*163.61*	*0.00371**	*2.55*
Macroeconomic variables				
Log of median of wage in the region of residence	*0.0702****	*11.55*	*0.0528****	*9.66*
Unemployment rate	*-0.0595****	*8,97*	*-0,0107*	*-0,660*
Size of the labor force	*0.0000001****	*138.95*	*3.94e-08****	*9.77*
Time period dummies	*Yes*		*Yes*	
Constant	*8.242****	*177.06*	*8.337****	*197.32*
Adjusted R^2	*0.272*		*0.219*	
Number of observations	*2445423*		*2445423*	

Significance level: ""p<0.05, "**"p<0.01, "***" p<0.001*

Note. The dependent variable is the log of annual earnings.

The standard errors are heteroskedasticity robust and clustered at the individual level

Education clearly demonstrates increasing returns to the level of education. In this case the reference category is selected to be education below the gymnasium level. OLS estimation shows that individuals with gymnasium have 6.5% higher earnings while FE estimation suggests that earnings increase only for 0.29%. Possession of less than 2 years of the post-gymnasium level of education leads to an earnings increase of 21.8% applying OLS. FE reports 6.7% increase in earnings for this category of individuals. More than 2 years of post-gymnasium education increases earnings for 26.3 % with OLS for 14.5% with FE estimation. Finally, OLS estimation shows that degree of Master or PhD increases the earnings by 42% whereas FE shows a 22.1% increase. Individuals of foreign origin receive on average 6% lower earnings than natives.

Sector of employment significantly influences individuals' earnings. In this setting, individuals employed in the public sector such as health care, defense, public order and social administration were selected to be the baseline category. OLS estimation suggests that individuals employed in manufacturing receive 7% higher wages than in public services. On the contrary, results obtained by using FE shows that individuals employed in manufacturing experience a penalty of 0.7%. The explanation of these results might lie in the fact that in manufacturing the percentage of workers covered by collective agreements is less than the corresponding percentage in public services. Individuals employed in construction receive 5.4% higher annual income according to the results from OLS estimation and 2.1% higher with FE. Such an evident increase can be explained by the high riskiness of the job, and by the working conditions of workers employed in construction. Employment in the retail sector is associated with a 4.8% increase using OLS and 0.08% increase using FE. OLS suggest that individuals employed in the private service sector receive 13.1% higher annual earnings than individuals in the reference category. FE estimation shows only a 0.3% increase in annual earnings for this category of workers. In general, it should be noted that these results are consistent with a quite compressed earnings distribution across economic sectors. Macroeconomic variables behave in the expected fashion. The logarithm of median wage in the labor market of work positively and significantly affects earnings. The Unemployment rate affects

earning negatively suggesting downward an existing a wage curve for the male part of population in Sweden. In the same time, the size of the labor market have a positive impact on earnings [12].

Generally speaking, it is possible to conclude when individual heterogeneity is not controlled for, the magnitude of most coefficients, and their significance levels, are severely inflated.

Table 7. Estimation results using FE. Alternative male sample specifications.

Sample	*Number of observations*	*Commuting distance*	*Squared commuting distance/100*
Sample including individuals with commuting distances >240 km	*2485651*	*0.000233*** (9.80)*	*-0.0000828*** (-6.10)*
Sample including commuting distances>240 older than 25 years	*2398402*	*0.000315*** (9.29)*	*-0.000162*** (-5.93)*
Sample including individuals with commuting distance >240 km who does work in agglomeration	*1198665*	*0.000317*** (10.32)*	*-0.000106*** (-6.41)*
Sample including individuals with commuting distance >160 km who does work in agglomeration	*1168319*	*0.000377*** (8.48)*	*-0.000166** (-4.67)*
Sample including individuals with commuting distance >160 km who does work in agglomeration and older than 25 years	*114618*	*0.000379*** (8.42)*	*-0.000164*** (-4.55)*

t-values are in parenthesis
Significance level: ""p<0.05, "**"p<0.01, "***" p<0.001*
Note: The dependent variable is the logarithm of annual earning of individual.
The standard errors are heteroskedasticity robust and clustered at the individual level

To check the robustness of the obtained coefficients, a set of additional sample restrictions were tested. Previous studies suggest that age is positively correlated with mobility patterns, with the peak of mobility being between 20 and 25 years. Moreover, individuals in this age group receives lower income due to the lack of experience and low social capital. Therefore, we expected to observe a higher commuting premium for individuals which are above the peak of the commuting age threshold. Apart from that, many urban economics studies suggest that enterprises located in

[12] The set of regional fixed effects was included in order to test for the labor market heterogeneity. Results indicate that the introduction of Labor market fixed effects does not improve significantly the value of the coefficients of interest. Therefore, we do not report them in the output tables.

larger agglomerations offer higher wages or give higher bargaining power to their employees due to higher productivity. The results are presented in the Table 5.

Results in Table 7 clearly support the thesis we just postulated. The return to commuting is higher for individuals older than 25 years. Moreover, individuals who work in urban agglomerations experience a higher return to commuting, likely due to more efficiently developed infrastructure facilities, availability of the fast-speed transport modes or agglomeration effects on productivity.

6. Analysis of the female sample

The outcome from the female sample with the OLS and FE estimation methods are presented in Table 8. The magnitude and significance levels of the coefficients of the distance variables support the concavity assumption of the commuting distance profile in the earnings equation. The coefficient of the linear term of commuting distance is 0.000684 and the quadratic term is -0.000076 using the OLS, and 0.000301 and -0.000217 using FE estimation. These results suggest that female individuals with hourly wage of 174 SEK (19.33 EUR) receive a financial compensation for 1 hour of commuting equal to 33SEK (3.66EUR) which constitutes 17% of their hourly wage when using OLS, and 14 SEK (1.5 EUR) which is 8,4% according to FE estimation procedure.

The OLS estimated coefficients on the age dummies suggest that earnings steadily increase with the age up to 55 years with a subsequent fall. The results from the fixed effect estimation suggest that the turning point occurs somewhat later than for males: approximately in the 40-45age group.

Marital status significantly affects the wage of female workers. The results from OLS estimation suggest that married women earn 0.6% less than single women, whereas FE results indicated that married women have a 0.9 % higher earnings that single ones. These results can be also explained by the redistribution of the tasks in household production. Females living in cohabitation show an annual earning premium of 0.5% according to OLS, and a 0.7% premium according to FE estimation. Single mothers experience a significant penalty which is 3% in OLS and almost 4% in FE estimation. Education plays an important role in the wage formation of female individuals. As before, the reference category was selected to be females with education lower than gymnasium level. The result from OLS estimation indicate that the individuals with gymnasium level of education receives 4% higher earnings than the baseline category. FE suggests that the increase is around 6%. Post-gymnasium level of education shorter than 2 years increases earnings by 17.9% with OLS, and 13.3% with FE estimation. Individuals with the post-gymnasium level of education receive on average 21% more than the reference category. A university degree accounts for a 42.2% earnings' increase according to OLS estimation, and 30.6% increase according to FE estimation.

Table 8. Estimation results using OLS and FE. Female sample

Variables	*Female sample OLS estimation*		*Female sample Fixed effect estimation*	
	coefficient	*t-value*	*coefficient*	*t-value*
Distance variables				
Distance	*0.000684****	*30.22*	*0.000301****	*7.80*
Square distance/100	*-0.000076****	*-3.46*	*-0.00021****	*-6.69*
Age variables				
Age between 25 and 30	*0.0185****	*11,47*	*0.1285****	*65,30*
Age between 30 and 35	*0.0565****	*34,61*	*0.2001****	*81,23*
Age between 35 and 40	*0.0901****	*56,54*	*0.2348****	*77,79*
Age between 40 and 45	*0.0947****	*62,72*	*0.2443****	*72,22*
Age between 45 and 50	*0.0936****	*63,38*	*0.2367****	*64,25*
Age between 50 and 55	*0.0972****	*66,42*	*0.2233****	*56,14*
Age between 55 and 60	*0,0986*	*67,64*	*0,2078****	*48,49*
Family status variables				
Married	*-0.00646****	*-12.21*	*0.00901****	*7.70*
Living in cohabitation	*0.00598****	*7.60*	*0.00784****	*6.43*
Single mother/father	*-0.0321****	*-15.64*	*-0.0379****	*-12.56*
Education level				
Gymnasium level of education	*0.0433****	*58.26*	*0.0641****	*8.03*
Post- gymnasium level of education <2 years	*0.179****	*137.12*	*0.133****	*15.33*
Post-gymnasium level of education >2 years	*0.210****	*262.03*	*0.213****	*24.66*
University level of education	*0.422****	*158.96*	*0.306****	*31.12*
Nationality	*-0.0177****	*-23.80*	.	.
Sector of employment				
Manufacture	*0.109****	*145.54*	*-0.0146****	*-7.20*
Construction	*0.0969****	*54.26*	*0.0179****	*5.14*
Retailing	*0.0604****	*84.86*	*-0.0136****	*-7.64*
Private services	*0.138****	*151.16*	*-0.00211*	*-1.16*
Log of median of wage in the region of work	*0.142****	*21.70*	*0.165****	*26.03*
Unemployment rate	*0.1091****	*15,00*	*0.0713****	*3,87*
Size of the labor force	*0.00000018****	*133.38*	*4.36e-08****	*9.87*
Time period dummies	*Yes*		*Yes*	
Constant	*8.669****	*172.34*	*8.965****	*182.55*
Adjusted R^2	*0.269*		*0.192*	
Number of observations	*1761593*		*1761593*	

Significance level: ""p<0.05, "**"p<0.01, "***" p<0.001*

Note. The dependent variable is the log of annual earning.

The standard errors are heteroskedastisity robust and clustered on individual level

As it was stated before, the distribution of individuals' earnings is quite compressed across sectors of employment in Sweden. Moreover, the earnings in different sectors are seriously affected by individual's heterogeneity. OLS reports the increase in earnings to be 11% in manufacturing

whereas FE shows earnings decrease by 1.4%. Construction shows an increase in earnings of 9.6% in case of OLS estimation and 1.7% in case of FE estimation. Individuals employed in retailing earn 6% more when using OLS, but according to the FE estimates these individuals experience a penalty of 1.3%. Working in private services leads to an increase in earnings of 13.8% derived using OLS, and a decrease in earnings of 0.2% with FE. One of the explanations of the clear penalty in employment in sectors other than the public sector is a higher protection against gender discrimination in the latter.

Table 9. Estimation results using FE. Alternative female sample specifications

Sample	*Number of observations*	*Commuting distance*	*Squared commuting distance/100*
Sample including individuals with commuting distances >240 km	*1775856*	*0.000142****	*-0.0000576****
		(5.02)	*(-3.35)*
Sample including commuting distances>240 older than 25 years	*1738885*	*0.000317****	*-0.000227****
		(8.14)	*(-6.93)*
Sample including individuals with commuting distance >240 km who does work in agglomeration	*793418*	*0.000160****	*-0.0000459****
		(4.19)	*(2.07)*
Sample including individuals with commuting distance >160 km who does work in agglomeration	*783525*	*0.000210****	*-0.0000952**
		(3.90)	*(-2.11)*
Sample including individuals with commuting distance >160 km who does work in agglomeration and older than 25 years	*775027*	*0.000212****	*-0.0000958**
		(3.92)	*(-2.11)*

Notes: The dependent variable is the logarithm of annual earning of individual;
t-values are in parenthesis
Note: Significance level: ""p<0.05, "**"p<0.01, "***" p<0.001*
The standard errors are heteroskedasticity robust and clustered at the individual level

Macroeconomic variables behave in the expected manner. Logarithm of median wage prevailing in the local labor market affects positively wages using both OLS and FE estimation, as do unemployment rate and size of the labor market. Curiously enough, we found that the unemployment rate is positively correlated with wage level, which contradicts the existence of a wage curve in Sweden. A possible explanation is that high unemployment benefits and immigration owing to the attractiveness (amenities) of a certain destination together with the level of wages established during bargaining between cartels of employers and labor unions generate such a result.

The additional sample restrictions were tested for the female sample as well. The results from the estimation are presented in Table 7.

The results are similar for the male and female samples. Although the magnitude of the return is much lower for females. Older individuals experience higher returns to commuting. Moreover, female individuals who work in urban agglomerations experience a higher return to commuting due to agglomeration effects on productivity or better developed infrastructures.

7. Estimation of the model using firm level fixed effect

In the same time we have estimated the earning model including firm level fixed effects in order to verify the existence of return to commuting for different commuting distances while controlling form firm-specific heterogeneity.

Table 10. Estimation results using firm level FE. Male and female sample.

Variables	*Male sample Fixed effect estimation*		*Female sample Fixed effect estimation*	
	coefficient	*t-values*	*coefficient*	*t-values*
Distance variables				
Distance	*0.00036****	*27.69*	*0.00033****	*20.54*
Square distance/100	*0.000031****	*3.67*	*0.00007****	*6.79*
Age variables				
Age between 20 and 25	*-0.031002****	*-30.13*	*-0.00092*	*-0.63*
Age between 25 and 30	*0.00223**	*-2.09*	*0.03438****	*22.46*
Age between 30 and 35	*0.04649****	*43.56*	*0.07629****	*50.12*
Age between 35 and 40	*0.07051****	*67.72*	*0.08726****	*59.99*
Age between 40 and 45	*0.07736****	*74.67*	*0.09222****	*64.30*
Age between 45 and 50	*0.08097****	*77.99*	*0.09874****	*69.19*
Age between 50 and 55	*0.08713****	*83.45*	*0.10206****	*71.50*
Age between 55 and 60	*0.08015****	*69.27*	*0.09621****	*63.47*
Family status variables				
Married	*0.076****	*174.74*	*-0.00202****	*-4.10*
Living in cohabitation	*0.04468****	*42.08*	*0.01178****	*15.64*
Single mother/father	*-0.03618****	*-38.41*	*-0.02335****	*-14.34*
Education level				
Gymnasium level of education	*0.05503****	*98.91*	*0.03612****	*0.00079*
Post- gymnasium level of education <2 years	*0.16741****	*202.62*	*0.15574****	*127.13*
Post-gymnasium level of education >2 years	*0.23229****	*336.76*	*0.22154****	*265.93*
University level of education	*0.45256****	*285.71*	*0.47628****	*263.10*
Nationality	*-0.04545****	*-68.58*	*.-0.00886*	*-13.07.*
Sector of employment				
Manufacture	*-0.02986****	*-12.20*	*-0.02311****	*-6.18*
Construction	*0.03121****	*16.78*	*0.02202****	*5.71*
Retailing	*0.00614***	*2.65*	*0.00379*	*1.25*
Private services	*0.01087*	*4.97*	*0.01377****	*4.89*
Macroeconomic variables				
Log of median of wage in the region of residence	*0.20477****	*35.86*	*0.26985****	*43.19*
Unemployment rate	*-0.17902****	*-23.55*	*-0.00968***	*-1.11*
Size of the labor force	*7.66e-07****	*107.89*	*1.79e-07****	*98.17*
Constant	*9.39906****	*214.64*	*9.6939****	*202.38*
Time fixed effects	*Yes*		*Yes*	

Table 10 (continued)

Adjusted R^2	*0.2700*	*0.2518*
Number of observations	*2720145*	*1905038*

Significance level: ""p<0.05, "**"p<0.01, "***" p<0.001*
Note. The dependent variable is the log of annual earnings.
The standard errors are heteroskedasticity robust and clustered at the individual level

The results in Table 8 indicate that the return to commuting is similar to the one calculated in the presence of individual heterogeneity. β-coefficient for the linear term of commuting distance is 0.00036 and quadratic term is 0.000013 in the male sample. In the same time, the results from the estimation of the female sample β-coefficient for the linear term is 0.00033 while coefficient on quadratic term is 0.00007. Therefore, the return to commuting increases with the distance at the increasing rate with higher increasing rate for the female sample. Again, assuming that males receive an hourly wage of 199 SEK (22 EUR) and females have 174 SEK (19.33 EUR), back of envelope calculations suggest that males gain 18.54 SEK (1.95 EUR) for one hour of commuting (35 kilometers) which constitutes around 9.34% of the hourly wage while females receives 17.53 SEK (1.83 EUR) one hour of commuting which is around 10.8% of the hourly wage. Therefore we can suggests that within firms individuals with higher commuting distance tend also to have higher wage. This fact can be seen as an explicit evidence of presence of individual's bargaining power.

8. Estimation of the wage growth model

One possibility is that individuals might accept lower current earnings over greater commuting distances if they expect a faster increase in their earnings over subsequent years. To analyze this possibility, we have estimated a model where the dependent variable is the difference in the earnings of individuals between 2003 and 2010. The analysis was focused on individuals who neither changed the place of residence nor the place of work during the time window considered. The results on the estimation for the male and female samples are shown in Table 11.

Table 11. Results on estimation of difference in log earnings using OLS in 2010-2003

Variable	*Male sample*		*Female sample*	
	B coefficient	*t-value*	*B coefficient*	*t-value*
Distance in 2003	*0.0000759**	*2.52*	*0.0000326*	*0.72*
Δ marriage 2010-2003	*0.00924****	*4.91*	*-0.00666****	*-3.56*
Δ cohabitation 2010-2003	*0.0332****	*9.21*	*0.0228****	*5.16*
Difference single parents 2010-2003	*0.0311****	*15.08*	*0.0638****	*25.57*
Δ education gymnasium 2010-2003	*0.313****	*15.98*	*0.161****	*9.07*
Δ education <2 years 2010-2003	*0.235****	*9.01*	*0.147****	*6.58*
Δ education >2 years 2010-2003	*0.265****	*11.01*	*0.249****	*10.32*
Δ university 2010-2003	*0.379****	*13.10*	*0.399****	*12.98*
Δ age 2010-2003	*0.0934****	*33.46*	*0.0918****	*29.95*
Δ squared age 2010-2003	*-0.000734****	*-93.96*	*-0.000633****	*-6373*
Δ median wage 2010-2003	*0.119**	*1.96*	*0.0772*	*1.19*
Δ employment rate 2010-2003	*-0.195**	*-1.93*	*0.122*	*1.08*
Δ size of labor market 2010-2003	*0.0000002**	*2.22*	*-0.0000002**	*-2.42*
Adjusted R^2	*0,247*		*0,0,213*	
Number of observations	*152522*		*146552*	

Significance level: ""p<0.05, "**"p<0.01, "***" p<0.001*
Note. The dependent variable is the difference between logs of earnings in the initial period (2003) and final period (2010).
The standard errors are heteroskedasticity robust and clustered at the individual level

The β-coefficient on earnings 0.0000759 indicates that the males on average experience higher earnings growth rate associated with commuting. It suggests that individuals who commute 60

km per day for round way distance would experience a 0. 4% higher earnings growth rate. The point estimate for females is 0.0000326 but are not statistically significant.

The results in this Section show that commuting on top of ensuring higher earnings immediately also contributes to a faster earnings' increase in the medium run.

9. Comparison of the results of estimation

One of the most important conclusions of our work is that the returns to commuting for the male and female samples do not vary too much. So to say, OLS reports 16% of hourly wage compensation for 1 hour of commuting whereas females receive 17% more. FE estimation reports approximately similar returns for 1 hour of commuting across genders, although lower in magnitude: 8.5% for the male sample and 7.5% for the female sample. In the same time results on estimation the model with inclusion of firm fixed effects suggests that women have slightly higher return to commuting (10.8%) comparing to men (9,34%) Also, commuting contributes to the earnings' growth rate of individuals in a middle run perspective. Males receive an additional 0.4% of earnings' growth rate per one hour of commuting. By contrast, the point estimates for the females are not significant in this case.

The age dummies as a proxy of working experience suggests that the experience profile is more concave for women with a later turning point (approximately between 45 and 50). Variables indicating marital status suggest that married or cohabitating individuals of both genders have higher earnings than single individuals. Single parents experience approximately similar earnings penalties both in magnitude and significance. Education is more rewarding for females. At the same time, female individuals employed in the sectors other than public service experience a decrease in earnings likely due to higher gender discrimination or "glass ceiling effects". Males employed in sectors different from public services do not experience significant increases in their earnings. It suggests the fact that the wage distribution across sectors is quite compressed. Macroeconomic variables affect the earnings of individuals of both genders in similar fashions and magnitudes.

To conclude, it is possible to say that males and females obtain approximately similar compensation for commuting. It can be viewed as an approximately similar bargaining power. Another explanation would be similar levels of efficiency during the spatial job-search process.

10. Conclusions

We provide evidence that the wage return to commuting is increasing in commuting distances within the borders of economically justified regions. Evidence of concavity, commonly reported by previous studies, is also found. In the same time we have provided evidence that commuting induces a faster earnings' growth rate for males in the medium-run. Moreover, there is no significant evidence of a gender gap in compensation for commuting in relative terms.

Our study addresses only one aspect of the reward from commuting, received through the job-search process under the form of higher compensation from the employer. We do not take into account the implicit compensation received by individuals from differences in the housing prices, availability of natural and social amenities, differences in taxation, and the availability of public goods. Moreover, this study does not allow identifying net gains or losses due to commuting because of unavailability of information on commuting expenses and losses in social capital or health related to commuting.

Positive returns to commuting can be attributed to the bargain power of individuals and the consequent thinness of the labor market, the efficiency of the job search process or differences in productivity across spatial units. Taking into account the wage formation process in Sweden, it is likely that the explanation provided by spatial differences in the employer monopoly power is also reasonable.

Our results provide some suggestions for further study. The current study which focuses on individual heterogeneity of employees can be usefully expanded to incorporate employer heterogeneity with employer-employee matched data, in order to capture differences in productivity between employers and the consequent possibility to compensate workers differently for their commuting distances. Moreover, the availability of variables which better reflect commuting expenses and labor supply (i.e. considering wages rather than annual earnings) would significantly increase the precision of our estimates and provide a precise answer to answer a crucial question, : what is the wage return to commuting.

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