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# Commuting and the Economic Milieu

## An Investigation of the Choice to Commute Related to Labor Demand, Worker Competition and Wage

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**Abstract**

*We calculate aggregate economic-milieu variables and use them as explanatory variables to study the Swedish commuting pattern. The variables are of accessibility type (i.e. spatially discounted) and are logarithmic ratios. We start from the assumption of utility maximizing individuals. The probability to commute using a link increases with expected utility. We apply two models: the quantity model and the wage model. The explanatory power is high and the results are as expected. Labor demand is positively related to utility. Worker competition is negatively related to utility. Wage is positively related to utility. A municipality, which is not a regional center, can strive to increase the number of jobs within the municipality. The second best, for such a municipality, is that jobs are available in the municipality that is the regional center. Otherwise, the municipality and region will economically decline.*

**Keywords:** commuting, economic milieu, accessibility, labor demand, worker competition, wage
**JEL code:** C51, J61, R12, R41

# 1. Introduction

Spatial aspects of economics affect all of us in many ways. A firm hires workers and sells to customers distributed in space. In open economies goods and services are often transported long distances. An individual travels more or less every day for many reasons. An individual commutes to work, makes shopping trips, and travels for leisure activities. Just the fact that most individuals spend much time commuting, makes it interesting and important to study.

Individuals maximize utility and firms maximize profit, and a part of the problem is to choose the best location. Our purpose is to model individual utility from commuting to a work municipality from a given other home municipality. In other words, we estimate the utility derived from commuting per home-work link. The industrial life is relatively more clustered in space than households. A simplified description of a region is

that it has a center municipality, with relatively more jobs than workers, that is surrounded by municipalities, with relatively more workers than jobs. An individual may work in the home municipality, in another municipality in the home region, or in another region.

# 2. Spatial interaction theory

A gravity model relates commuting to the size of the origin, the size of the destination and the distance (or travel time) between them. There are unconstrained and constrained gravity models, and the constrained models come in many forms (Sen & Smith 2011). It is for example possible to enforce that the size of the origin is maintained in the model as in reality. It is also possible to add more constraints, such as enforcing that the number of jobs in the model in each municipality is as in reality. It is possible to add more constraints, e.g. that the commuting time in the model, and that the number of commuters in the model is as in reality for different types of commuting (Johansson *et al*. 2002 & 2003). In such models, worker alternatives and competition is handled by the (many) balancing factors. In our models, the economic milieu variables are explicit and not buried in the balancing factors. We believe this is good for two reasons. First, we argue that it is in this way an individual looks at the world. And, by framing the problem in this way, we estimate how the individual utility is related to measures of the economic milieu. Second, this formulation is such that it is straight forward to discuss the results with politicians.

A region is formed from municipalities that are relatively more connected to each other, and a region often has a core and a periphery. In this paper, we use the so called functional-analysis regions defined by the Swedish Agency for Economic and Regional Growth (NUTEK). In the following we will use the term region. An individual can choose to work in the home municipality, in another municipality that belongs to the home region, or in another region. A worker not satisfied with the situation (e.g. home, work, and commute) strives to improve it. That means that a worker can search for a new job (closer to the present home), or search for a new home (closer to the present job), if not both. If a commute from the home municipality or from the home region is considered negative workers move and find new jobs so such commutes will be relatively rare. We study an individual's choice of work municipality, given where the individual lives. With this in focus, we investigate the following hypothesis:

> H1: An individual loses utility commuting from the home municipality. Commuting between regions gives an additional loss of utility.

Most workers have a relatively short commute, and it is rare to find a worker with a really long commute. The tendency for travel time to reduce interaction is illustrated in Fig. 1. The commuting pattern changes over time; the average commuting time has gradually increased, and the area under the curve in Fig. 1 has gradually shifted to the right. Nothing much happens to the pattern during a short time period, but over a longer period we have observed such changes. In Sweden, the daily average mobility of persons has increased from half a kilometer in the year 1900 to 45 kilometers in the year 1999 (Andersson & Strömquist 1988; SIKA 2000). SIKA was a Swedish government authority, and was replaced by Transport Analysis, which estimate that the 2011 mobility is 44 kilometers (Transport Analysis 2013).

The concept of accessibility was first introduced by Hansen (1959). Accessibility measures can be created in different ways and it is common to use measures of gravity

type. An accessibility measure of gravity type takes into account that the sizes of the involved municipalities as well as the distance between them are important (Song 1996). Measures of accessibility are frequently used: Johansson Klaesson and Olsson (2002) study labor market integration, Johansson Klaesson and Olsson (2003) study commuting, Andersson and Ejermo (2005) study knowledge sources and innovativeness of corporations, Karlsson and Olsson (2006) study how to define functional regions, Johansson and Karlsson (2007) study R&D and export diversity, Andersson and Gråsjö (2009) study representations of space in empirical models, and Öner (2014) study retail location. Martín and van Wee (2011) and Gråsjö and Karlsson (2013) summarize the usefulness of accessibility measures.

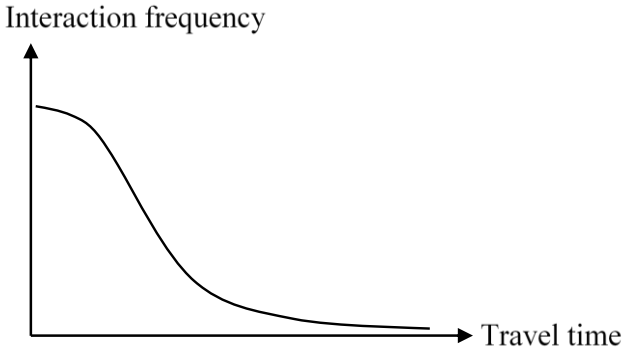


**Figure 1: Interaction declines with distance**

An individual lives in a municipality denoted by *i*. The number of individuals living in this municipality is denoted by $o_i$. We use *j* to denote a particular municipality where he/she chooses to work. The number of jobs in municipality *j* is denoted by $d_j$. The worker's choice is illustrated in Fig. 2. In this example, the individual could work in either of the six municipalities, $r_1$ to $r_6$.

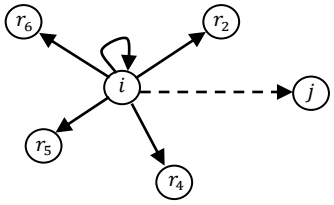


**Figure 2: An individual picks some place to work**

For each home municipality we define a measure of labor demand in a specific destination. An individual that lives in a specific home municipality is probably more inclined to commute to a destination if the number of jobs there, $d_j$, is large. The decision to commute from the home to the destination municipality is also affected by the travel time between the two municipalities, $t_{ij}$. An individual is probably more likely to commute if the travel time between the municipalities is short. When calculating this measure, we always use the appropriate travel-time frictions, $\lambda_{ij}$ (Johansson *et al*. 2003). There is one friction for commuting within the home municipality, $\lambda_0$, one for commuting between municipalities within the region, $\lambda_1$, and one for commuting

between regions, $\lambda_2$. The number of jobs in the destination municipality is therefore discounted by $\exp\{\lambda_{ij}t_{ij}\}$. Hence, the labor-demand measure is $f_{ij} = \exp\{-\lambda_{ij}t_{ij}\}d_j$. We argue that labor demand positively affects an individual. With this measure of the economic milieu we investigate the following hypothesis.

H2: Individual utility is positively related to labor demand.

Firms operating in municipality *j* choose who to employ. Workers living in municipality *i* are only one possible source of workers. Workers who live in surrounding municipalities and those who live in municipality *j* also compete over the jobs in *j*. The firm's choice is illustrated in Fig. 3. In this example the firm could employ workers from six municipalities, $s_1$ to $s_6$.

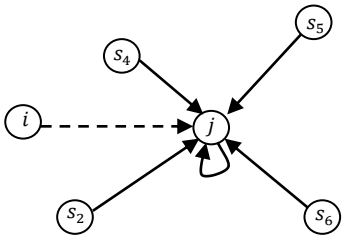


**Figure 3: Workers from all municipalities compete over the jobs**

If the worker competition is large in a municipality, an individual is less likely to commute there. For each destination, we define three measures of worker competition. With them, we take into account that workers compete over jobs. The numbers of competing workers, $o_s$, from different municipalities are discounted by $\exp\{\lambda_{sj}t_{sj}\}$. The local worker-competition measure is $g_j^{Loc} = \exp\{\lambda_{jj}t_{jj}\}o_j$. The regional worker-competition measure is $g_j^{Reg} = \sum_s k_{sj}\exp\{\lambda_{sj}t_{sj}\}o_s$. The corresponding inter-regional worker-competition measure is $g_j^{Int} = \sum_s l_{sj}\exp\{\lambda_{sj}t_{sj}\}o_s$. With these measures of the economic milieu we investigate the following hypothesis.

H3: Individual utility is negatively related to worker competition.

In our model, the jobs available differ in two characteristics: wage and location. The wage you earn differs across work municipalities. The commuting time, given a home municipality, also differs, since jobs are located in different municipalities. Jobs are compared, and in such a comparison, wages and distances would be included. The idea is that workers tend to commute to municipalities with high wages, but that this tendency is reduced with commuting time. In order to capture these job characteristics we define the wage measure as $h_{ij} = \exp\{-\lambda_{ij}t_{ij}\}w_j$. The final hypothesis has to do with the individual utility and wage.

H4: Individual utility is positively related to wage.

# 3. Models and estimation methods

We let indices $i$ and $j$ identify the Swedish municipalities, $i, j \in \{1, \dots, 289\}$. A worker lives in a municipality, $i$, and works in a municipality, $j$. We use $c_{ij}$ to denote the number of commuters on link $ij$. The sum of all commuting from one municipality equals the

local labor supply, $o_i = \Sigma_j c_{ij}$. The sum of all commuting into one municipality equals the local labor demand, $d_j = \Sigma_i c_{ij}$. The theoretical probability that an individual chooses a specific link is denoted by $\pi_{ij}$. In the same way, the theoretical probability that an individual chooses to work in the home municipality is $\pi_{ii}$.

## 3.1. Empirical specification for the quantity model

We assume that the individual utility, $U_{ij}$, of a particular link can be described by an additive random utility model, $U_{ij} = v_{ij} + \omega_{ij} = \alpha_{ij} + \mathbf{z}_{ij}\boldsymbol{\beta} + \omega_{ij}$ (McFadden 1973). In this expression, $\alpha_{ij}$ is a link specific constant, $\mathbf{z}_{ij}$ is a row vector of link information, $\boldsymbol{\beta}$ is a column vector of the corresponding parameters, and $\omega_{ij}$ is the error term. Note that we model the utility of a link, and not the utility of a job using a link. Therefore, our model introduces spatially-weighted variables in the individual utility function. We introduce a dummy variable, $k_{ij}$, which is 1 for commuting between municipalities, and zero otherwise. We introduce a dummy variable, $l_{ij}$, which is 1 for commuting between regions, and zero otherwise. This enables us to sort out the effects on utility from passing a (municipality and regional) border per se, and via labor demand, worker competition, and wage.

In the model, we have the economic-milieu measures as link information. In that way we get a multinomial-logit model of commuting and the economic milieu. Here $\alpha_{ij} = \alpha_0$ for commuting in the home municipality, $\alpha_{ij} = \alpha_1$ for commuting between municipalities within the home region, and $\alpha_{ij} = \alpha_2$ for commuting between regions. We specify the vector with link information as $\mathbf{z}_{ij} = \left[\ln(f_{ij}) \quad \ln(g_j^{Loc}) \quad \ln\left(g_j^{Reg}\right) \quad \ln(g_j^{Int})\right]$, and the column vector $\boldsymbol{\beta} = [\beta_0 \cdots \beta_3]'$ contains the corresponding parameters. The error term, $\omega_{ij}$, enables individuals to make different choices. The error term also captures changes over time, e.g. decisions on where to work. In this model the measures of the economic milieu are pairwise related such that the elasticity of substitution is constant.

We assume that $\beta_0$ is positive. This implies that the utility function with respect to labor demand is increasing and concave. We assume that $\beta_1$, $\beta_2$ and $\beta_3$ are negative. This implies that the utility function with respect to worker competition is decreasing and convex. We also assume that $\alpha_2 < \alpha_1 < \alpha_0$. In this study, we focus on the commuting that takes place between municipalities. That means that we are interested in finding out the effects of labor demand and worker competition on such commuting.

We assume that the residuals are independently and identically distributed with the type I extreme-value distribution (Maddala 1983). Then the probability that an individual who lives in municipality $i$ chooses to work in municipality $j$ is $\pi_{ij} = \exp\{v_{ij}\}/\Sigma_j \exp\{v_{ij}\}$. There are corresponding expressions for $U_{ii}$ and $v_{ii}$, which give that the probability to work in the home municipality is $\pi_{ii} = \exp\{v_{ii}\}/\Sigma_j \exp\{v_{ij}\}$. To be able to estimate the parameters in the utility function, we study the relative commuting pattern in logarithmic form, $\ln(\pi_{ij}/\pi_{ii})$. We only include commuting between municipalities in the analysis, $k_{ij} = 1$. However, we use local commuting as reference. The ratio between the two probabilities is $\pi_{ij}/\pi_{ii} = \exp\{v_{ij} - v_{ii}\}$, leading to our theoretical model given in (1).

$$\ln(\pi_{ij}/\pi_{ii}) = v_{ij} - v_{ii} = \alpha_{ij} - \alpha_0 + \left[\mathbf{z}_{ij} - \mathbf{z}_{ii}\right]\boldsymbol{\beta} \qquad (1)$$

Substituting $p_{ij}$ and $p_{ii}$ into the left hand side of (1), and defining the dependent variable as $y_{ij} = \ln(p_{ij}/p_{ii})$, yields the empirical specification given in (2).

$$y_{ij} = \alpha_{ij} - \alpha_0 + [\mathbf{z}_{ij} - \mathbf{z}_{ii}]\boldsymbol{\beta} + \varepsilon_{ij} \quad (2)$$

We put $y_{ij}$ into a column vector $\boldsymbol{y}_i = [y_{i1} \cdots y_{i289}]'$ and stack them into a vector $\boldsymbol{y} = [\boldsymbol{y}_1' \cdots \boldsymbol{y}_{289}']'$. The link specific variable vector is $\mathbf{x}_{ij} = [1 \quad l_{ij} \quad \mathbf{z}_{ij} - \mathbf{z}_{ii}]$. We get our variable matrix, $\mathbf{x}$, by stacking these row vectors together, $\mathbf{x} = [\mathbf{x}_1' \cdots \mathbf{x}_{289}']'$, where $\mathbf{x}_i' = [\mathbf{x}_{i,1}' \cdots \mathbf{x}_{i,289}']'$. Using this notation our empirical specification of the model is given in

$$\mathbf{y} = \mathbf{x}\boldsymbol{\gamma} + \boldsymbol{\varepsilon} \quad (3)$$

In this model, $\boldsymbol{\gamma}$ contains the parameters from the utility function: $\boldsymbol{\gamma} = [\gamma_0 \cdots \gamma_5]' = [\alpha_1 - \alpha_0 \quad \alpha_2 - \alpha_1 \quad \beta_0 \cdots \beta_3]'$. The constant, $\gamma_0$, identifies the effect commuting to another municipality has on utility. The regional constant, $\gamma_1$, identifies the effect commuting to another region has on utility. Our first hypothesis is that an individual consider it negative to commute from the home municipality and home region. We expect that $\gamma_0 < 0$ and $\gamma_1 < 0$. That means that we certainly expect that $\gamma_0 + \gamma_1 < 0$. This is a log-linear model so the parameters $\gamma_2$, ⋯, $\gamma_5$ are elasticity measures. Our second hypothesis is that labor demand is positively related to utility. That means that we expect that $\gamma_2 > 0$. Our third hypothesis is that worker competition is negatively related to utility. We expect that $\gamma_3 < 0$, $\gamma_4 < 0$, and $\gamma_5 < 0$.

## 3.2. Empirical specification for the wage model

In this model the labor demand and worker competition variables are replaced by the wage variable. That means that we consider spatial wage differences as the result of variations in labor demand and worker competition.

In this model, $\boldsymbol{\gamma}$ contains the parameters from the utility function: $\boldsymbol{\gamma} = [\gamma_0 \quad \gamma_1 \quad \gamma_6]' = [\alpha_1 - \alpha_0 \quad \alpha_2 - \alpha_1 \quad \beta_4]'$. The constant, $\gamma_6$, identifies the wage effect on utility. We expect that $\gamma_6 > 0$.

An alternative (not pursued) would be to add the wage variable to the quantity model. In that way we could allow wage differences for other reasons. We use aggregate data, and have no information on the existing productivity differences between municipalities. The production is not the same in all municipalities. For example, there is a relatively large public sector in some municipalities.

## 3.3. Estimation method

We let $C_{ij}$ be a stochastic variable counting the number of commuters from municipality $i$ to municipality $j$. Then $\Sigma_j C_{ij} = o_i$ and $\Sigma_j \pi_{ij} = 1$ for each home municipality. In this way there are 289 different multinomial distributions as each home municipality represents a node. The expected number of individuals using the link $ij$ is $\mathrm{E}(C_{ij}) = o_i \pi_{ij}$, the variance of $C_{ij}$ is $\mathrm{Var}(C_{ij}) = o_i \pi_{ij}(1 - \pi_{ij})$ and the covariance is $\mathrm{Cov}(C_{ij}, C_{ir}) = -o_i \pi_{ij} \pi_{ir}$ where $j \neq r$. The estimator $P_{ij} = C_{ij}/o_i$ of $\pi_{ij}$ is unbiased with variance $\mathrm{Var}(P_{ij}) = \pi_{ij}(1 - \pi_{ij})/o_i$ and covariance $\mathrm{Cov}(P_{ij}, P_{ir}) = -\pi_{ij}\pi_{ir}/o_i$ where $j \neq r$. That means that the dependent variable in this model (3) is a logarithmic ratio that is heteroskedastic and dependent.

By construction, we can only include links with positive commuting. That means that all inactive links are ignored. We adjust the dependent variable to correct for the

conditioning on only active links, $\mathbf{y}_{adj} = \mathbf{y} - \ln\left(1 - \left(1 - p_{ij}\right)^{o_i}\right)$. We estimate the model (4) and calculate the standard errors in two ways.

$$\mathbf{y}_{adj} = \mathbf{x}\boldsymbol{\gamma} + \boldsymbol{\varepsilon} \quad (4)$$

In the first way, we estimate the model using robust ordinary least squares to account for heteroskedasticity. We calculate $\widehat{\mathrm{Cov}}(\hat{\boldsymbol{\gamma}}) = (\mathbf{x}'\mathbf{x})^{-1}\mathbf{x}'\mathrm{diag}(\mathbf{e} \circ \mathbf{e})\mathbf{x}(\mathbf{x}'\mathbf{x})^{-1}$ and calculate the standard errors from the diagonal. We would like to also account for dependencies in the data. In the second way, we therefore calculate $\widehat{\mathrm{Cov}}(\hat{\boldsymbol{\gamma}}) = \sum_i (\mathbf{x}_i'\mathbf{x}_i)^{-1}\mathbf{x}_i'\mathbf{e}_i\mathbf{e}_i'\mathbf{x}(\mathbf{x}_i'\mathbf{x}_i)^{-1}$ and calculate the standard errors from the diagonal.

# 4. Data

We got the data from Statistics Sweden and The National Swedish Road Administration. One of the data sets consists of aggregated commuting data for 2006. The other data set consists of travel time by car between municipalities for 2004. The number of municipalities changes over time. At this time Sweden had 289 municipalities. Investments in infrastructure and speed adjustments change the time matrix. However, we assume that the changes from 2004 to 2006 are small. Therefore the 2004 travel time data was merged to the 2006 commuting data. We focus on the daily commuting patterns in Sweden. For that reason we introduce 90 minutes as a one-way time limit in the regression. In the calculation of the variables we apply a 150 minute time limit. Moreover, all links without commuting are omitted. The Swedish Agency for Economic and Regional Growth define a functional analysis region as a region in which individuals can live and work without having to make too time-consuming commutes (NUTEK 2013). The way the functional analysis regions are created form regions with municipalities with high level of internal interaction. We argue that the results would be similar using other delimitation procedures (e.g. local labor market and commuting zones). The reason is that most municipalities would be grouped in the same way, independent of approach.

## 4.1. Total

In Table 1 we have collected descriptive statistics for our variables. The variables are all link specific, and the table just provides summary information. We use the logarithm of the relative commuting probability, $\ln(p_{ij}/p_{ii})$ as our dependent variable.

**Table 1: Descriptive statistics of variables**

| Variable | Minimum | Average | Maximum | Standard deviation |
|---|---|---|---|---|
| Commuting probability | -10.91 | -6.03 | 0.84 | 2.00 |
| Labor demand | -10.98 | -2.51 | 3.48 | 1.93 |
| Worker competition | -2.61 | 0.02 | 2.61 | 0.63 |
| Wage | -8.27 | -2.54 | 1.08 | 1.44 |

In our measures of the economic milieu, we have travel-time frictions, $\lambda_{ij}$, to account for the negative impact of travel time. Johansson *et al*. (2003) estimated constrained gravity models. We have estimated the gravity models for 2006 according to their method to get up to date friction parameters. The friction parameter for commuting within the home municipality is $\lambda_0 = 0.15$. The friction parameter for commuting between municipalities

within the home region is $\lambda_1 = 0.10$. The friction parameter for commuting between regions is $\lambda_2 = 0.05$.

The models have three economic-milieu variables. Our intention with them is to capture the complex variation of the economic milieu. The first variable is the logarithm of the ratio between the labor-demand measure in the destination municipality and the corresponding measure at home, $\ln(f_{ij}/f_{ii})$. The second economic milieu variable is the logarithm of the ratio between worker-competition measure in the destination municipality and the corresponding measure in the home municipality, $\ln(g_j/g_i)$. By construction this variable is symmetric. The third economic-milieu variable is the logarithm of the ratio between the wage measure in the destination municipality and the wage measure in the home municipality, $\ln(h_{ij}/h_{ii})$. It is important to note that the spatial variation of worker competition is relatively small. This is explained by that workers search for a job in a time circle around their home municipality, and therefore competition (as we defined it) is smoothed out across municipalities. Our economic-milieu variables are intertwined. We present a correlation matrix in Table 2. Here, we see that labor demand, worker competition and wage are positively correlated. In other words, there is a tendency for municipalities with relatively high labor demand also to have a relatively high level of worker competition and a relative high wage level. The diagonal of the correlation matrix (excluding the commuting probability) give us that the variance inflation indicators are 2.5, 1.2 and 2.2 for labor demand, worker competition and wage. This is an indication that we do not have large multi-collinearity problems.

**Table 2: A correlation matrix**

| Variable | Commuting probability | Labor demand | Worker competition | Wage |
|---|---|---|---|---|
| Commuting probability | 1.00 | 0.64 | 0.21 | 0.44 |
| Labor demand | | 1.00 | 0.33 | 0.71 |
| Worker competition | | | 1.00 | 0.04 |
| Wage | | | | 1.00 |

## 4.2 Men and women

We also estimate the models on data for men and women alone. In such a model, we treat the male and female labor market as completely separated. This contrasts to the estimations using aggregate data. All variables are calculated for men and for women. In the creation of the spatially weighted economic-milieu variables we use gender specific travel-time frictions (Table 3).

**Table 3: Travel-time friction**

| Commute | Men | Women | Total |
|---|---|---|---|
| Local | 0.14 | 0.15 | 0.15 |
| Regional | 0.09 | 0.11 | 0.10 |
| Between regions | 0.05 | 0.06 | 0.05 |

# 5. Results

In this study, we report the results from including commuting flows with up to a 90-minute one-way commute. The reason for this choice is that we are interested in daily

commuting. We have tested the model for other time limits (both smaller and larger), and the model works well then too.

## 5.1. Total

Overall the models fit the data well, and the results support our hypotheses. Here, it is worth to repeat that our variables are in logarithmic form and spatially discounted.

We have collected the results from the quantity model and wage model in Tables 4 and 5, respectively. Individuals much prefer to work in the home municipality. We observe a large negative impact on utility from commuting to another municipality. In addition to this negative effect from leaving the home municipality, we observe a large additional negative impact on utility from commuting to another region. This supports our first hypothesis. We observe that labor demand has a positive effect on utility. This supports our second hypothesis. We observe that worker competition has a negative impact on utility, since $\hat{\gamma}_3 < 0$, $\hat{\gamma}_3 + \hat{\gamma}_4 < 0$, and $\hat{\gamma}_3 + \hat{\gamma}_4 + \hat{\gamma}_5 < 0$. This supports our third hypothesis, but it really is the local part that matters. We observe that wage is positively related to utility, which supports our fourth hypothesis.

**Table 4: The parameter estimates, standard error, lower and upper limit, and R^2 for the total data set using the quantity model. Robust estimation to handle heteroscedasticity.**

| Variable | Estimates | $SE_{White}$ | $SE_{Cov}$ | Lower | Upper |
|---|---|---|---|---|---|
| Municipality constant | -2.052 | 0.024 | 0.039 | -2.129 | -1.975 |
| Inter-regional constant | -2.644 | 0.018 | 0.035 | -2.713 | -2.575 |
| Labor demand | 0.926 | 0.008 | 0.012 | 0.902 | 0.950 |
| Local worker competition | -0.319 | 0.013 | 0.023 | -0.364 | -0.274 |
| Regional worker competition | 0.015 | 0.008 | 0.016 | -0.016 | 0.046 |
| Interregional worker comp. | -0.019 | 0.011 | 0.020 | -0.058 | 0.020 |
| $R^2$ | 0.984 | | | | |
| # observations | 7,139 | | | | |

**Table 5: The parameter estimates, standard error, lower and upper limit, and R^2 for the total data set using the wage model. Robust estimation to handle heteroscedasticity.**

| Variable | Estimates | $SE_{White}$ | $SE_{Cov}$ | Lower | Upper |
|---|---|---|---|---|---|
| Municipality constant | -2.237 | 0.045 | 0.091 | -2.415 | -2.059 |
| Inter-regional constant | -2.566 | 0.032 | 0.065 | -2.693 | -2.439 |
| Wage | 0.864 | 0.012 | 0.024 | 0.818 | 0.910 |
| $R^2$ | 0.959 | | | | |
| # observations | 7,139 | | | | |

## 5.2. Men and women

The results are mostly the same using data separated by gender.

**Table 6: The parameter estimates, standard error, lower and upper limit, and R^2 for men using the quantity model. Robust estimation to handle heteroscedasticity.**

| Variable | Estimates | $SE_{White}$ | $SE_{Cov}$ | Lower | Upper |
|---|---|---|---|---|---|
| Municipality constant | -2.127 | 0.022 | 0.034 | -2.193 | -2.061 |
| Inter-regional constant | -2,142 | 0.017 | 0.032 | -2.204 | -2.080 |
| Labor demand | 0.909 | 0.008 | 0.011 | 0.888 | 0.930 |
| Local worker competition | -0.300 | 0.012 | 0.021 | -0.340 | -0.260 |
| Regional worker competition | 0.011 | 0.008 | 0.015 | -0.018 | 0.040 |
| Interregional worker comp. | -0.027 | 0.011 | 0.018 | -0.062 | 0.008 |
| $R^2$ | 0.983 | | | | |
| # observations | 6,814 | | | | |

**Table 7: The parameter estimates, standard error, lower and upper limit, and R^2 for men using the wage model. Robust estimation to handle heteroscedasticity.**

| Variable | Estimates | $SE_{White}$ | $SE_{Cov}$ | Lower | Upper |
|---|---|---|---|---|---|
| Municipality constant | -2.395 | 0.044 | 0.085 | -2.561 | -2.229 |
| Inter-regional constant | -2.058 | 0.032 | 0.062 | -2.179 | -1.937 |
| Wage | 0.806 | 0.012 | 0.025 | 0.758 | 0.854 |
| $R^2$ | 0.953 | | | | |
| # observations | 6,814 | | | | |

**Table 8: The parameter estimates, standard error, lower and upper limit, and R^2 for women using the quantity model. Robust estimation to handle heteroscedasticity.**

| Variable | Estimates | $SE_{White}$ | $SE_{Cov}$ | Lower | Upper |
|---|---|---|---|---|---|
| Municipality constant | -2.259 | 0.029 | 0.035 | -2.328 | -2.190 |
| Inter-regional constant | -2.118 | 0.021 | 0.034 | -2.184 | -2.052 |
| Labor demand | 0.836 | 0.008 | 0.011 | 0.814 | 0.858 |
| Local worker competition | -0.219 | 0.013 | 0.021 | -0.260 | -0.178 |
| Regional worker competition | -0.003 | 0.008 | 0.015 | -0.033 | 0.027 |
| Interregional worker comp. | -0.015 | 0.012 | 0.019 | -0.052 | 0.022 |
| $R^2$ | 0.982 | | | | |
| # observations | 5,689 | | | | |

**Table 9: The parameter estimates, standard error, lower and upper limit, and R^2 for women using the wage model. Robust estimation to handle heteroscedasticity.**

| Variable | Estimates | $SE_{White}$ | $SE_{Cov}$ | Lower | Upper |
|---|---|---|---|---|---|
| Municipality constant | -2.550 | 0.050 | 0.087 | -2.721 | -2.379 |
| Inter-regional constant | -2.025 | 0.037 | 0.069 | -2.161 | -1.889 |
| Wage | 0.740 | 0.012 | 0.022 | 0.697 | 0.783 |
| $R^2$ | 0.951 | | | | |
| # observations | 5,689 | | | | |

# Discussion

An individual has to decide what and how much to consume. He/she also has to decide where to live, where to work and what mode of transportation to use (McFadden 1973). Differences in travel behavior between different groups of individuals have been studied in various situations (Olsson 2002; Johansson *et al*. 2002; Johansson *et al*. 2003; Sandow & Westin 2010; Faith-Ell & Levin 2012). On average, women earn less, work fewer

hours, and have larger responsibilities for the household and children. Thereby women are more sensitive to travel time (Camstra 1996). Individuals with a higher degree of education are, on average, less sensitive to travel time. This is a consequence of the fact that jobs that require higher education imply higher wages and often are concentrated to certain places (Johansson *et al*. 2002). It would be interesting to estimate our models for categories of workers, defined by gender and education. It would also be interesting to do the analysis for different occupational groups. However, this requires a data set with more information. An additional complication is that individuals form households, with spatial effects. It may affect both where you live and where you work. It would also be interesting to incorporate relationship status into our models.

In this study, we focus on out commuting, i.e. commuting from a given home municipality to a chosen work municipality. In such a study, wages are certainly important. House prices, on the other hand, are not. It is possible to reverse the study, and focus on where a worker chooses to live, given a work municipality. Then, house prices are important, while wages are not. Given a work municipality, where would workers choose to live? In such a model we would also alter the two milieu variables; i.e. relative labor supply and relative work competition.

Municipalities have different roles in the spatial context; some are job centers while others are relatively popular places to live. The economic milieu changes over time, due to that urbanization and local specialization is an on-going process. Therefore, it would be most interesting to include the development over time in the model. Moreover, infrastructure investments directly affect the economic milieu. Particularly, it would be interesting to include available modes of transportation for each link.

We find that an individual loses utility from leaving the home municipality. This can be used as an argument for industrial policies at the municipality level. However, municipalities have different roles; some are net suppliers of workers while others are net supplier of jobs. We find that an individual loose utility from commuting out of the region. This can be interpreted in the way that it is important that the job centers of a region grow. It is important to get a bigger industrial life in the region, but not necessarily in each municipality. In the peripheral parts it may be more efficient to create nice locations for living. What happens in the core of a region is important also for those living in the peripheral parts of the region. A municipality and region that does not succeed in this work will see that the inhabitants move to other regions.

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