

Spatial distribution of US employment in an urban wage-efficiency setting*

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Abstract

In this paper, we analyze the spatial distribution of US employment and earnings against an urban wage-efficiency background, where leisure and effort at work are complementary. Using data from the American Time Use Survey (ATUS) for the period 2003-2014, we analyze the spatial distribution of employment across metropolitan areas. We also empirically study the relationship between individual earnings and commuting and leisure. Our empirical results show that employment is mostly concentrated in metropolitan cores, and that earnings increase with “expected” commuting time, which gives empirical support to our urban wage-efficiency theory. Furthermore, we use Geographical Information System models to show that there is no common pattern of commuting and the employees-to-unemployed rate, although we find higher wages in comparatively crowded states, where average commuting times are also higher

Keywords: urban wage-efficiency, earnings, commuting, leisure, American Time Use Survey.

JEL Codes: J21, J22, J31, R12, R41.

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1. INTRODUCTION

In this paper, we analyze the spatial distribution of US employment, against an urban wage-efficiency background. We also analyze individual earnings and their relationship to effort at work, leisure, and commuting. Analyses of employment and earnings and their spatial distribution are common in several fields, and there is a rich literature in economics of commuting time (see Ma and Bannister, 2006, for a chronological review) and its interactions with employment and wages. We offer updated evidence of the spatial distribution of US wage employment and individual earnings, with a focus on commuting, leisure, and effort at work, according to a theoretical model that contrasts more commuting time with less time in leisure, and where leisure time and effort at work are complementary concepts. Employees who devote comparatively more time to commuting have comparatively less time to devote to leisure activities, and thus have incentives to shirk, which decreases their effort at work and, consequently, reduces their productivity.

Employment and earnings have been studied in a variety of frameworks, with the urban wage-efficiency theory being one approach. Wage-efficiency models are an important field of research in economics. In these models, salaried workers receive higher wages than those that correspond to the labor market equilibrium in order to not shirk. In other words, firms are willing to pay workers more than expected to promote efficiency and discourage shirking. However, firms do not pay enough to eliminate all shirking if they do not observe individual time endowments (Shapiro and Stiglitz, 1984). The so-called Urban Wage-Efficiency models include a spatial pattern, where location of jobs and living places play an important role, with the main objective being to study how employment and unemployment are distributed between the city center and the city fringe. By including this spatial background, certain new, key aspects are considered, with one important factor being the distance from the living place to the job place, which determines the time devoted to commuting.

Commuting, the distribution of wealth in cities, and urban wage-efficiency models have been intensively studied. Brueckner, Thisse and Zenou (1997) study the location of individuals in cities by income. Zax and Kain (1991) find that commuting changes affect the quit rates of black workers, but do not affect the quit rates of their white counterparts. The Spatial Mismatch Theory (Kain, 1968) argues that poor labor market outcomes are partly the result of spatial separation between job and living places. This

is an important concept in these models, and its effects on unemployment have been studied in Brueckner and Zenou (2003) (the contributions in this field are reviewed in Gobillon, Selod and Zenou, 2007). Patacchini and Zenou (2007) show the growing spatial dependence of unemployment rates. Picard and Zenou (2015) study the spatial distribution of individuals by social interactions, finding that minority groups have higher unemployment rates, independently of where they are located.

The effect of commuting on wages has already been studied (Manning, 2003; White, 1999; Zax, 1991), and the effects of commuting (determined by the spatial distribution of living places and jobs) and leisure on shirking have been theoretically and empirically examined by Ross and Zenou (2003, 2006), although their empirical results are not conclusive. Zenou (2006) develops a spatial model of employment and housing, showing that efficiency wages increase with commuting distance. Our approach is the same as that adopted in Ross and Zenou (2006), and we complement their results with current US time-use data.

Within this framework, our primary goal is to test the positive relationship between commuting time and earnings for the employed, and to show that, in general, commuting time has a negative relationship with employment, which can be interpreted as that the unemployed are located far from where employment is concentrated. We use the American Time Use Survey (ATUS) for the years 2003-2014, which includes information on commuting time, individual earnings, leisure, and other individual characteristics, to apply our empirical model. We find that, on average, “expected” commuting time is negative and significantly related to employment, in line with Ross and Zenou (2006). Furthermore, we examine the relationship between “expected” commuting and wages, finding the relationship is positive and significant. In particular, we find that a 1-minute increase in the “expected” commuting is positively associated with increases of around 1% in real hourly wages. We also propose Geographical Information System (GIS) modeling of commuting vs. employees over unemployment rates and wages. GIS models are useful tools in showing descriptive information with spatial trends, due to their nature and simplicity and the intuition of their results, as they show the data distributed according to geographical location.

We contribute to the literature by giving empirical support to Ross and Zenou (2003, 2006), and complementing urban results about employment and wages. First, we draw on time-use data, which have been underused in this field, although the ATUS has

been previously used in commuting analyses that have provided positive and consistent results (Gimenez-Nadal, Molina and Velilla, 2015; 2016). Second, our statistical results show that workers are mainly located close to work-places and wages are positively related to “expected” commuting, which is consistent with urban wage-efficiency theories and with the notion of substitutability between shirking and leisure, propounded by Ross and Zenou (2003, 2006). Third, we make use of GIS models, to show that states with the higher average commutes also present higher average wages, although there is no clear pattern across commuting, population, and areas of employment.

The rest of the paper is organized as follows. Section 2 briefly describes our urban wage-efficiency background. Section 3 describes the data, and in Section 4 we show our empirical results. Section 5 contains our GIS maps, and Section 6 presents our main conclusions.

2. THEORETICAL BACKGROUND

Urban wage-efficiency models are strongly developed and offer a robust theoretical framework to test our empirical work. We take the urban wage-efficiency model of Ross and Zenou (2006) as our reference theoretical framework to make our hypothesis about what is expected from the empirical analysis. These authors construct a model whose main hypothesis is the following: leisure time and shirking at work are substitutive concepts. Put simply, the more time devoted to commuting, the less time individuals are able to devote to shirking. From this hypothesis, it is expected that commuting time and shirking are positively related, since long commuting times imply less leisure time, which in turn implies more shirking. However, it is also theoretically possible that leisure and shirking are complementary concepts, and this relationship depends on the form of the utility function and how leisure and effort at work are related.

When firms do not have control over workers’ location (i.e., over commuting times, and where shirkers and non-shirkers are located), wages are exogenous and the two previously-argued relationships between leisure and shirking are possible. When shirking and leisure are substitutive, workers who reside close to jobs will not shirk, and higher wages implies less shirking. This is clear because workers who live close to their

jobs will have less commuting time and thus more leisure, so they will shirk at work less, according to the substitutability hypothesis. On the other hand, when shirking and leisure are not substitutive, then spatial distribution is unclear. However, if some extra conditions are imposed (unemployment spells are not too long, so the savings to shirkers from commuting costs of being unemployed are not too high), then shirking workers will live close to their jobs (i.e., near the city center). Again, under the hypothesis of complementarity, the relationship is conceptually clear, since workers who reside closer to their work-places will have less commuting time and more leisure, so they will shirk more.

When firms do have control over workers' location, there will be no shirking in the equilibrium because firms will not hire shirking workers (they are able to know which workers will provide more effort at work). In this case, wages will not be exogenous and they will depend on commuting. When shirking and leisure are substitutive, then wages will increase with commuting, because the more commuting, the more incentives to shirk due to leisure loss, and firms must compensate for this leisure loss since all workers must have the same satisfaction level in the equilibrium. On the other hand, when they are complementary, wages will decrease with commuting because the more commuting, the less incentive to shirk (the conceptual interpretation is analogous).

We will make use of this conceptual framework in our empirical analysis. According to this model, we propose that leisure and shirking are substitutive concepts and then we make use of the derived results: the more commuting time, the higher earnings, and a negative relationship between commuting and employment (vs. unemployment). Thus, we propose two hypotheses, to be tested below. The first refers to the spatial location of workers. We hypothesize that employed workers are located closer to job places, compared to the unemployed from their potential job places, which means that commuting time is negatively related to the probability of being employed. The second hypothesis refers to employees' wages. Because the more commuting, the more incentives to shirk, firms will encourage efficiency via higher earnings. Then, we propose that expected commuting times follow a positive relationship to earnings.

3. DATA AND VARIABLES

We use the American Time Use Survey (ATUS) for the period 2003-2014 to analyze

the relationship between employment, earnings and commuting. Respondents are asked to fill out a diary, and thus the ATUS provides us with information on individual time use. The ATUS includes a set of ‘primary’ activities, including commuting. The database also includes some personal, family, demographic, and labor variables. The ATUS is administered by the Bureau of Labor Statistics, and is considered the official time use survey of the United States. More information can be found in <http://www.bls.gov/tus/>. The advantage of our data over microdata surveys based on stylized question is that diary-based estimates are more accurate (Juster and Stafford, 1985; Robinson, 1985; Bianchi et al., 2000; Bonke, 2005; Yee-Kan, 2008).

We restrict our sample to those individuals between the ages of 16 and 65, who are not retired or students, in order to minimize the role of time-allocation decisions that have a strong inter-temporal component over the life cycle, such as education and retirement. Furthermore, given that our main focus is on employed vs. unemployed, and the earnings of those who are employed, and their relationship with commuting time, we additionally restrict the sample to those two categories. Additionally, since there is no sense in talking about wage-efficiency in self-employment, as they do not receive wages, we will limit our sample of workers to those who are employees.¹ Figure 1 shows the evolution of the employment and unemployment rates in the US, using ATUS, and we observe two opposite directions: employment has decreased while unemployment has increased over the period. Apart from economic conditions, which influence employment and unemployment rates, among the reasons to explain these opposite trends we find that commuting time for the employed has increased, which affects shirking and thus effort at work (i.e., a higher wage is needed). When we look at the evolution of both hourly earnings and the commuting time of those who work during the period (Figure 2), we observe that commuting has increased, which may indicate that effort at work has decreased leading to increases in unemployment rates. The increase in commuting time in recent years is consistent with the findings of Kirby and LeSage (2009), McKenzie and Rapino (2009) and Gimenez-Nadal and Molina (2014,2016).

Furthermore, in order to test the effects of commuting on hourly wages, for those who work we restrict the analysis to working days, defined as those days where

¹ A complete modeling and analysis of the relationship between commuting and self-employment can be found in Gimenez-Nadal, Molina and Velilla (2016).

individuals spend more than 60 minutes working, excluding commuting.² The reason to restrict the sample of employed workers to working days is to avoid computing zero minutes of commuting to any worker who filled out the time use diary on Saturday, Sunday, or a holiday, which would affect our computation of “expected” commuting. The final sample consists of 46,299 individuals: 5,651 unemployed, 33,360 private sector employees, and 7,288 public sector employees.

The fact that we have information on the 24 hours of the day allows us to compute the total time devoted to both commuting and leisure, and see the relationship between the two. According to our model, commuting and leisure are substitutes, in the sense that the more time is devoted to commuting, the less time is devoted to leisure. Regarding commuting time, we consider the time devoted to the activity “commuting to/from work”, coded as “180501” in the ATUS codebook. For leisure time, we use the definition used in Gimenez-Nadal and Sevilla (2012). Figure 3 plots the average time devoted to leisure for each time devoted to commuting; that is, for all the diaries with the same amount of time devoted to commuting, we average the time devoted to leisure. For instance, for all workers with 1 hour of commuting, we average the time devoted to leisure and we obtain a mean value of leisure of 2 hours. We plot mean leisure time (x-axis) on the time devoted to commuting (y-axis). We have also added a linear fit of leisure on commuting time. We observe that the relationship between commuting and leisure is negative, as shown by the negative slope of the linear fit. Thus, the correlation between commuting and leisure is -0.212, indicating that the relationship between the two uses of time is negative. This result is consistent with one of the hypotheses of the model, where commuting and leisure are substitutes.

One important issue is that our model relates commuting time to the probability of employment, comparing unemployed and employed worker, and commuting time is not observed for the unemployed, apart from the fact that reported (i.e., real) commuting time may differ from “expected” commuting time of the employed. Furthermore, using reported commuting time for the employed in the analysis of earnings may lead to endogeneity problems. Here we follow Ross and Zenou (2006) and predict commuting

² We have repeated the analysis without restricting by working days, but controlling for weekdays, and results are qualitatively the same. Results are available upon request. For the restriction to working days, we define the variable “market work time” as the time devoted to the sum of “work, main job (not at home)”, “working nec (not at home)”, “work-related activities nec (not at home)”, “work & related activities nec (not at home)” and “waiting work related activities (not home)”.

time for both the unemployed and the employed. In doing so, we use the Heckman (1979) technique and we estimate a Heckman's two-step 2-equation model where, in one of the equations (participation equation), we estimate the probability of being employed vs. being unemployed, and in the second we estimate the time devoted to commuting controlling by selection into employment.

For identification of the participation equation, we rely on the existing literature on the relationship between culture and labor force participation decisions (Antecol, 2000; Fernandez and Fogli, 2009; Fernandez, 2007; 2011), which basically holds that differences in cultural origin may affect labor-force participation decisions. To identify participation into employment vs. unemployment, we use several variables to control for the cultural origin of respondents. We include whether the respondent is born in the US or not (American), whether the respondent has American citizenship conditioned on being born abroad (Naturalized Citizen), whether the father was born in the US (Father US), and whether the mother was born in the US (Mother US).

Regarding the commuting equation, we include two exogenous variables: gender (ref.: females) and race (ref.: white), since prior research has found that males have comparatively longer commutes than females (see Gimenez-Nadal and Molina, 2016, for a review), and individuals of different races combine modes of transport differently (US Census Bureau, 2015), which may affect their commuting time. Additionally, we follow Ross and Zenou (2006) and include variables measuring certain regional factors: we consider the demographic location of individuals, following the US Census Bureau's categorization of metropolitan areas. Despite that the Census Bureau's terminology for metropolitan areas, and the classification of specific areas changes over time, the general concept is consistent: a metropolitan area consists of a large population center and adjacent communities that have a high degree of economic and social interaction. The geographic information included in the ATUS includes a categorization of households as to whether they are in the central city within a metropolitan area, on the fringe of a metropolitan area (or just in a metropolitan area if no distinction is made) or in a non-metropolitan area. Some small metropolitan areas do not have a central city/outlying area distinction, so households in those areas are excluded from the analysis. We define three dummy variables as follows: metropolitan (central city within a metropolitan area), fringe metropolitan (fringe of a metropolitan area, the reference category) and non-metropolitan. Furthermore, we use the information about the size of

the area of residence. The ATUS includes information about the population size of the metropolitan area in which a household is located, coded as follows: 1) up to 100,000 inhabitants, 2) 100,000-249,999 inhabitants, 3) 250,000-499,999 inhabitants, 4) 500,000-999,999 inhabitants, 5) 1,000,000-2,499,999 inhabitants, 6) 2,500,000–4,999,999 inhabitants, and 7) 5,000,000+ inhabitants.

Table A1 of our Appendix shows the results of estimating a two-step Heckman model on commuting with selection into participation in employment. We observe that being American is negatively related to the fact of being employed, in comparison to the unemployed; this may be due to unemployed non-American individuals who return to their countries. On the contrary, being a US citizen is positively related to being employed, as also is the fact that the father is American. However, mother’s nationality is not related to employment. In the case of commuting time, we observe that the size of the metropolitan area has a positive relationship to the time devoted to commuting, that the location of residence (i.e., metropolitan vs. non-metropolitan) also matters, and that female and white individuals have comparatively shorter commuting times than their male and non-white counterparts. Furthermore, the inverse of mills ratio, included in the commuting equation to control for sample selection, is positive and statistically significant.

Table 1 shows a descriptive analysis of the variables, by group (employees vs. unemployed). We also show p -values of the non-parametric Kruskal-Wallis test, which is more general than a mean comparison test (such as t or ANOVA test) because it checks whether the probability that a random observation of a variable from each group is equally likely to be above or below a random observation from another group. Furthermore, if we assume that the group-distributions under the null hypothesis of equal means are the same, then it can be interpreted as a test of equality of means, although it is more accurate than a t -test in our study because the latter relies on normality assumption, which is not our case.³ However, when we compare these p -values with those obtained from the corresponding t -test or χ^2 -test, we find that all are qualitatively similar.

We observe that employees devote on average of 38.01 minutes daily to commuting, with a standard deviation of 40.62. If we now focus on the “expected

³ Figure A1 in the Appendix shows the k-density function of the time devoted to commuting by the employed in both the private and public sector. We can easily assume that commuting time does not follow a normal distribution.

commuting” of employed and unemployed individuals, we observe that the average time in “expected commuting” is 25.52 and 25.48 minutes per day for the employed and the unemployed, respectively, with standard deviations of 6.35 and 6.39. Because they are predictions, the standard deviation considerably decreases for the employed when we consider current and “expected” commuting, and when we compare the time of “expected” commuting for the employed and the unemployed, the Kruskal-Wallis test shows that the average times of “expected” commuting for the two groups are equal.

The ATUS also includes information on labor earnings, which allows us to estimate the hourly wage of workers. We have defined “hourly earnings” directly as earnings per hour, if this data was available from ATUS; in other case, we have defined it as earnings per week divided between the usual weekly working hours. Data collected in ATUS are in nominal terms, and thus we have transformed nominal hourly wages to real hourly wages by dividing nominal wages by the price deflator from the Federal Reserve, Bank of St. Louis (<https://research.stlouisfed.org/fred2/series/USAGDPDEFAISMEI>). For workers, the average hourly earnings’ mean is 19.48, and the standard deviation is 18.13.

We have defined other variables that may affect self-employment, such as gender (male), *potential* years in labor market (age minus number of education years and minus a fixed value, taken as 3), education level (dummy variables for primary education, secondary education, and university education), living in couple, partner’s labor force status (a dummy variable that indicates whether or not the partner works), number of children, being a naturalized U.S. citizen, being white, and being American. We consider three levels of education: “basic education” (less than high school diploma), “secondary education” (high school diploma), and “university education” (more than high school diploma). We have also included “age squared” and “years in labor market squared” (Ross and Zenou, 2006) in order to measure non-linear effects.

According to Table 1, and in comparison with the unemployed, the employed have a comparatively higher proportion of women (50.9% vs 45.4%), are on average older (42.19 years old vs 39.21) and thus have a more years in the labor market, a higher proportion have university education (66.4% vs 46.8%), have a greater probability of living in couples (60.8% vs 46.1%), have fewer children (0.97 vs 1.09), and a higher percentage are naturalized citizens, Americans, and white. Furthermore, the unemployed tend to live in more densely-populated areas than employees. However,

there are no differences in the fact of living in non-metropolitan areas between the unemployed and employees (approximately 15% of both groups). This may be because both employees and the unemployed have incentives to live in urban cores, either for ease of access to work or looking for job offers.

4. ECONOMETRIC STRATEGY AND RESULTS

We analyze two outcomes. The first one refers to the decision to participate in the labor market, or not (i.e., being employed or unemployed), and the second refers to hourly earnings for those who participate in the labor market, with a focus on the relationship between “expected” commuting and the two outcomes.

We first analyze the probability of being employed, compared to being unemployed, with a focus on the “expected” commuting time of individuals. To that end, we estimate a logit model on employment where, for a given individual i , let E_i be the dummy variable “employed” that takes value “1” if i is an employed worker, and value “0” if i is unemployed. By hypothesis, E follows a binomial distribution, $E_i \sim B(p_i, n_i)$. Then, C_i represents the expected commuting time of individual i , Y_i includes a set of socio-demographic variables, and ε_i represents random variables capturing unmeasured factors and measurement errors. We estimate:

$$\text{logit}(E_i) = \ln \left(\frac{p_i}{1-p_i} \right) = \beta_0 + \beta_1 C_i + \beta_2 Y_i + \varepsilon_i \quad (1)$$

where the logit function is directly related to the probability of being employed. Thus, if a parameter estimation is positive (negative), we should interpret it as follows: when the corresponding independent variables increase, the logit function of being employed increases (decreases), and thus the probability of being employed increases. The set of socio-demographic variables includes age (and its square), potential years in the labor market (and squared), dummy variables to control for secondary and university education (reference is primary education), being white, being American, living in couple, couple’s labor force status (working (1) vs non-working (0)), the number of children, and gender (ref., female). Given our theoretical model, we would expect that commuting time has a negative relationship to the probability of being employed, i.e., $\beta_1 < 0$.

For the earnings model, we estimate OLS regressions on the logarithm of hourly earnings. We estimate the transformation to logarithm because the distribution of the variable does not follow a normal distribution (see Figure A2 in the Appendix) and thus we try to normalize the variable by applying a log transformation. The statistical model is as follows:

$$X_i = \alpha_0 + \alpha_1 C_i + \alpha_2 Y_i + \epsilon_i \quad (2)$$

We choose the same vector Y_i as in the previous model. We also include industry and occupation fixed effects. In this case, as there is no sense in extending the model to the unemployed, because they do not receive wage earnings, we limit the sample to employees only. However, despite that we have real wages for all individuals in the sample of employees, we use “expected” commuting in order to avoid endogeneity problems. It could be that there are unmeasured factors that are correlated with both commuting time and real wages, and thus using real wages in this context would lead to endogeneity problems. For instance, it could be that individuals with better spatial skills are better drivers, and thus spend less time in commuting, and their spatial skills also allow them to be more productive at work and thus have a job with a higher relative wage.

Given our theoretical framework, and according to the literature on earnings and commuting, we would expect that commuting time has a negative relationship to employment, $\beta_1 < 0$ (i.e., the more commuting time, the less probability of being employed). However, the effect of commuting over wage earnings is expected to be positive, $\alpha_1 > 0$ (van Ommeren, van den Berg and Gorter, 2000; Ross and Zenou, 2003 and 2006; Rouwendal and Nijkamp, 2004; Dargay and van Ommeren, 2005; Susilo and Maat, 2007; Rupert, Stancanelli and Wasmer, 2009; Gimenez-Nadal and Molina, 2014; Gimenez-Nadal, Molina and Velilla, 2016).

Furthermore, since we are using generated regressors in the OLS and logit models, we follow Pagan (1984), Murphy and Topel (1985), Gimenez-Nadal and Molina (2013), and Gimenez-Nadal and Molina (2016), and bootstrap the standard errors of the regressions. In doing so, we have produced 500 replications of the model, where a random sample with replacement is drawn from the total number of observations. We also force our standard errors to be robust regarding homoskedasticity.

Results

Table 2 shows the results of estimating Equation (1). Column (1) shows the results for the full sample, while Columns (2) and (3) shows the results for employment in the private and public sectors, respectively. We find that “expected” commuting time presents a negative and statistically significant correlation with the probability of employment in general (Column (1)), and in both the private (Column (2)) and public sectors (Column (3)). These results are consistent with our theoretical framework, as we hypothesized a negative relationship between commuting and the probability of employment. These results can be interpreted as that employed workers tend to live nearer to where jobs are located than do the unemployed.

Furthermore, men have a higher probability of being employed than women; years working has an inverted U-shaped relationship with employment levels (which means that the probability of being employed increases with age until a certain point and then it begins to decrease); the higher the educational level, the higher the probability of being employed; white individuals are more likely to be employed than non-whites, although American individuals present the opposite pattern (which may be due to the fact that non-American individuals who do not have a job return to their countries); individuals who live in couple also have a higher probability of being employed, but the number of children is negatively related to this probability (couples with children need to devote time to their care, which implies less time for other activities, such as commuting or market-work, and thus it is more likely that women in these couples will be unemployed (Gimenez-Nadal and Molina, 2016).

Table 3 shows estimates of real hourly wages. As the supervision level plays a main role in wage-efficiency theory, for employees in the private sector we distinguish between supervised and unsupervised jobs, following Levenson and Zoghi (2007).⁴ Column (1) shows estimates for earnings across private sector employees, and Columns (2) and (3) shows the results considering whether employees in the private sector have a non-supervisory or supervisory job, respectively. Column (4) shows estimates for earnings across public sector employees. We find that estimated relationships do not vary across the private sector, supervised, not-supervised, and public sector models. In

⁴ We take as supervised the following occupation: “Management, business and financial”, “Professional and related”, “Service” and “Sales and related”. This leaves us with “Office and administrative support”, “Farming, fishing and forestry”, “Construction and extraction”, “Installation, maintenance and repair”, “Production” and “Transportation and material moving” as unsupervised occupations.

fact, in all of these cases, results are in line with what we expected from our theoretical framework. We find that “expected” commuting time is positive and statistically significant correlated with earnings. In particular, we give support to the theoretical modeling of Ross and Zenou (2003, 2006). In particular, we find that a 1-minute increase in the “expected” commuting is positively associated with increases of around 1% in all the subsamples.

For the rest of the variables, men are paid higher wages, potential years in the labor market has an inverted U-shaped relationship with earnings, indicating that, on average, maximum earnings are reached in adult years, but later decrease; earnings also increase with educational level and are higher for white workers (consistent with Brueckner and Zenou, 2003), but not for public-sector workers, whose earnings are not related to race in certain cases; being American is not related to earnings; living in couple is also related to higher earnings, which contrasts with the relationship of the number of children (which again is not related to earnings of public-sector workers in all cases).

5. GIS MODELING

We now propose a spatial analysis of employment, wages, and commuting, making use of Geographical Information System (GIS) models. GIS were originally created to be used in the field of Geography, and are based on the projection of variables and characteristics over a map using geographical attributes (latitude and longitude) of the physical position of the information analyzed. The results of GIS models are maps, so the spatial pattern is in the intrinsic nature of GIS. Thus, these results are an illustrative way of showing descriptive information with spatial trend. GIS is not a common tool in economics, although it has been used in certain empirical studies about commuting, with small samples and information about individuals who live in the same city (Kwan and Kotsev, 2015; Shen, Kwan and Chai, 2013; Kwan, 2004; or Kwan, 2000).

The ATUS provides us with information on the US Metropolitan Statistical Area (MSA) of residence of each individual. Thus, our modeling is not at the city level, but a national one. We represent for each MSA, over a US map, the average commuting and the rate of salaried employees over the unemployed; we repeat the analysis with average earnings, instead of the employment rate. One limitation of GIS is that it cannot be used to make inference, only to show descriptive spatial information.

Figure 4 shows average commute times and employment over unemployment rates by State. We find that the North-East Coast zone concentrates long commuting times. However, there is no clear relationship between commuting, population, and employment. There are crowded states with long average commuting times and low rates of employees over unemployed, such as California, Georgia, and Florida, but also with high rates: Virginia, Maryland, Delaware, Washington DC, and Rhode Island, for example. If we now consider the physical size of these states, we can see that the former are larger than the latter. Thus, there are physically small but densely-populated states that present longer average commuting times and also the higher proportion of employees over unemployed. Since many institutions, firms, and Universities are located in these states, there is no surprise in this result. On the other hand, lightly-populated states in the mid-North of the US also present high proportions of employees over unemployed, although in this case the average commuting times are short. We can consider that in these States there is a low labor demand, and many unemployed individuals will tend to move to other places looking for better job opportunities. Thus, these zones are mainly formed by employed individuals who tend to move near to their work-places, which helps to explain the obtained result.

Figure 5 shows average commute times and wages by State. In comparison to the previous map, the longer commuting times and the higher wages are found mainly in the East Coast states and California, while the mid-North states present the lower average wages, according to their higher and lower commuting times, respectively. Furthermore, there is again no clear relationship between wages and employees over unemployed rates.

6. CONCLUSIONS

This paper analyzes employment and earnings against an urban wage-efficiency background, with a focus on the spatial pattern of employment. We take the theoretical model of Ross and Zenou (2006) as a benchmark. Making use of the ATUS for the years 2003-2014, we analyze the relationship between “expected” commuting, on the one hand, and employment probability and earnings, on the other hand. Our results show that commuting is negatively related to employment. Thus, employees from both the public and private sectors tend to live near their jobs, compared to the unemployed

ones who, on average, live further from the places where the jobs are located. Furthermore, earnings are positively related to commuting times, which is also consistent with our theoretical framework. Thus, we have found current evidence for US of the Ross and Zenou (2006) theoretical modeling and, in particular, of their hypothesis about the substitutability of leisure and shirking at work. Our results contribute to the literature by empirically complementing and giving support to urban wage-efficiency models. We also make use of time-use data to analyze the U.S. labor market, which has been underused in this field.

Furthermore, we use GIS models and find that the longer the average commuting time (by state), the higher the average wage. Thus, the highest wages are concentrated in the most densely-populated states. Furthermore, when we consider the physical size of states, we observe that relatively small states, with relatively large populations, concentrate the highest wages, the longest commuting times, and the highest rates of employees over unemployed.

Our analysis does have certain limitations. First, by using cross-sectional data, we cannot talk about causal effects but only relationships. It is not clear whether commuting time affects earnings, or vice-versa. Furthermore, on making use of cross-sectional data, we must take into account the effect of non-empirically-controllable variables that may determine employment and wages. Second, in our analysis we only consider the demand side of the job market, in the sense that only workers' decisions are analyzed, and the supply side of job positions is not considered. This limitation is very important in the current context, as for instance the availability of jobs is important in determining whether individuals remain unemployed or prefer to be employed. Further analysis should extend our results by incorporating individual unobserved heterogeneity, and should include the supply side of the market.

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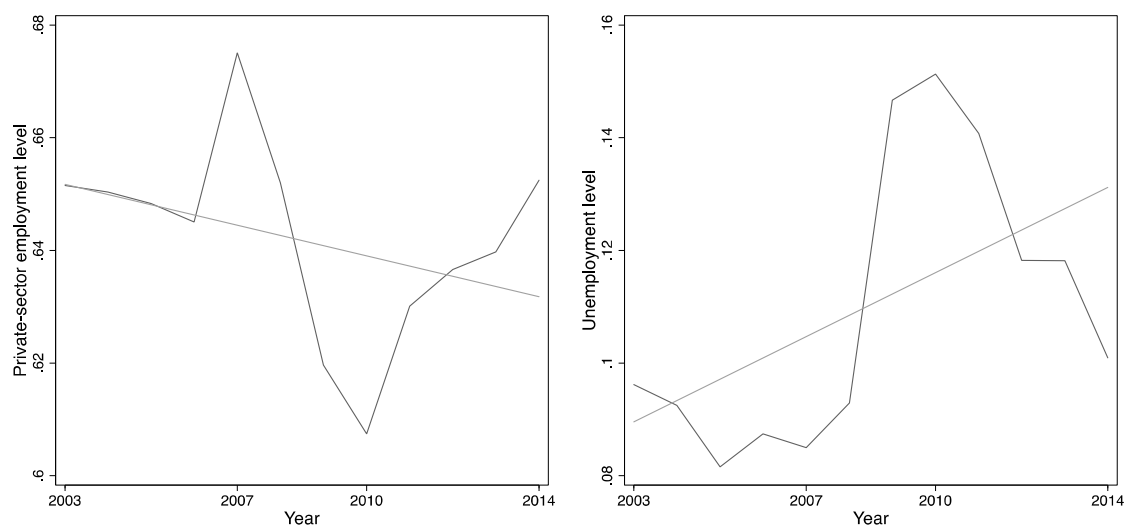
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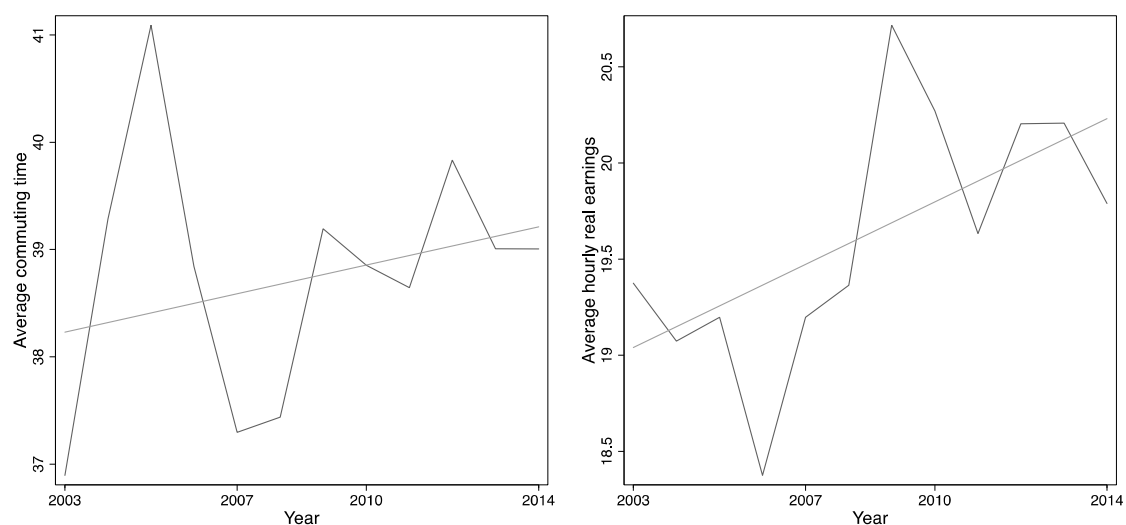
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Figure 1
Evolution of employment



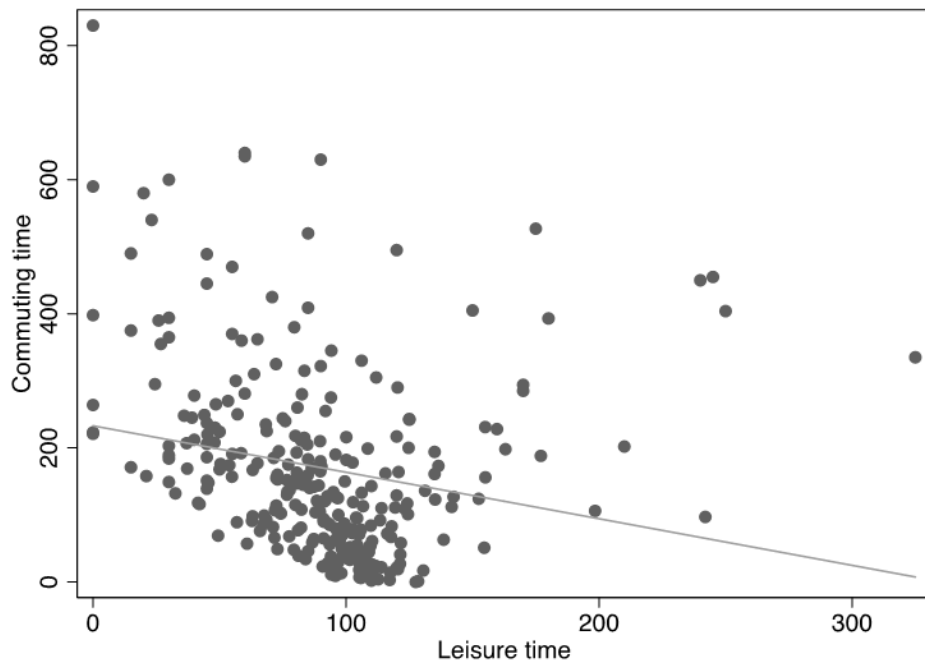
Note: The sample (ATUS 2003-2014) is restricted to employees or unemployed individuals. Levels are measured in points per unit.

Figure 2
Evolution of commuting and hourly earnings



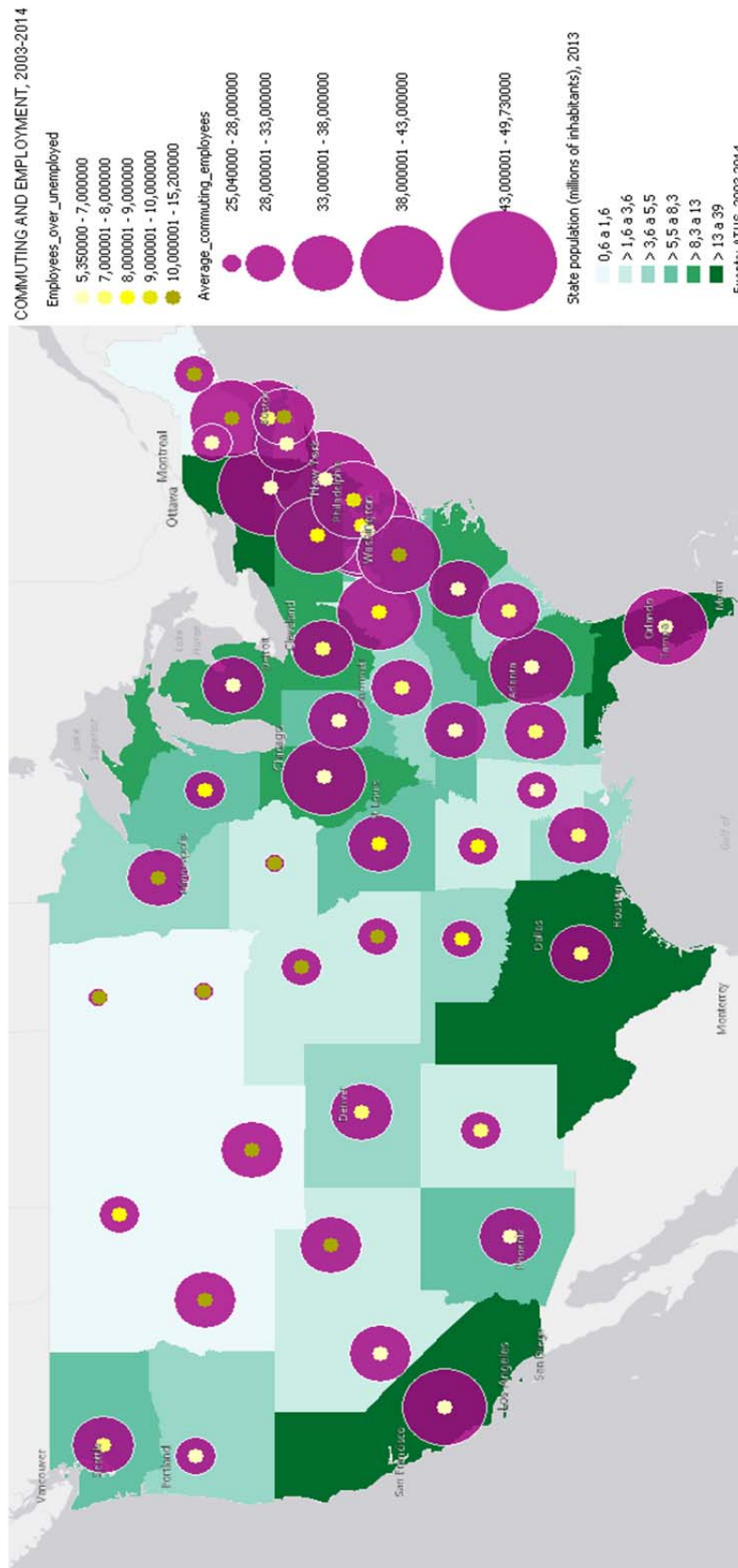
Note: The sample (ATUS 2003-2014) is restricted to employees. Average hourly earnings measured in Dollars per hour, deflated using the deflator of the Federal Reserve, Bank of St. Louis. Commuting time is measured in minutes per day.

Figure 3
Relationship between commuting and leisure times



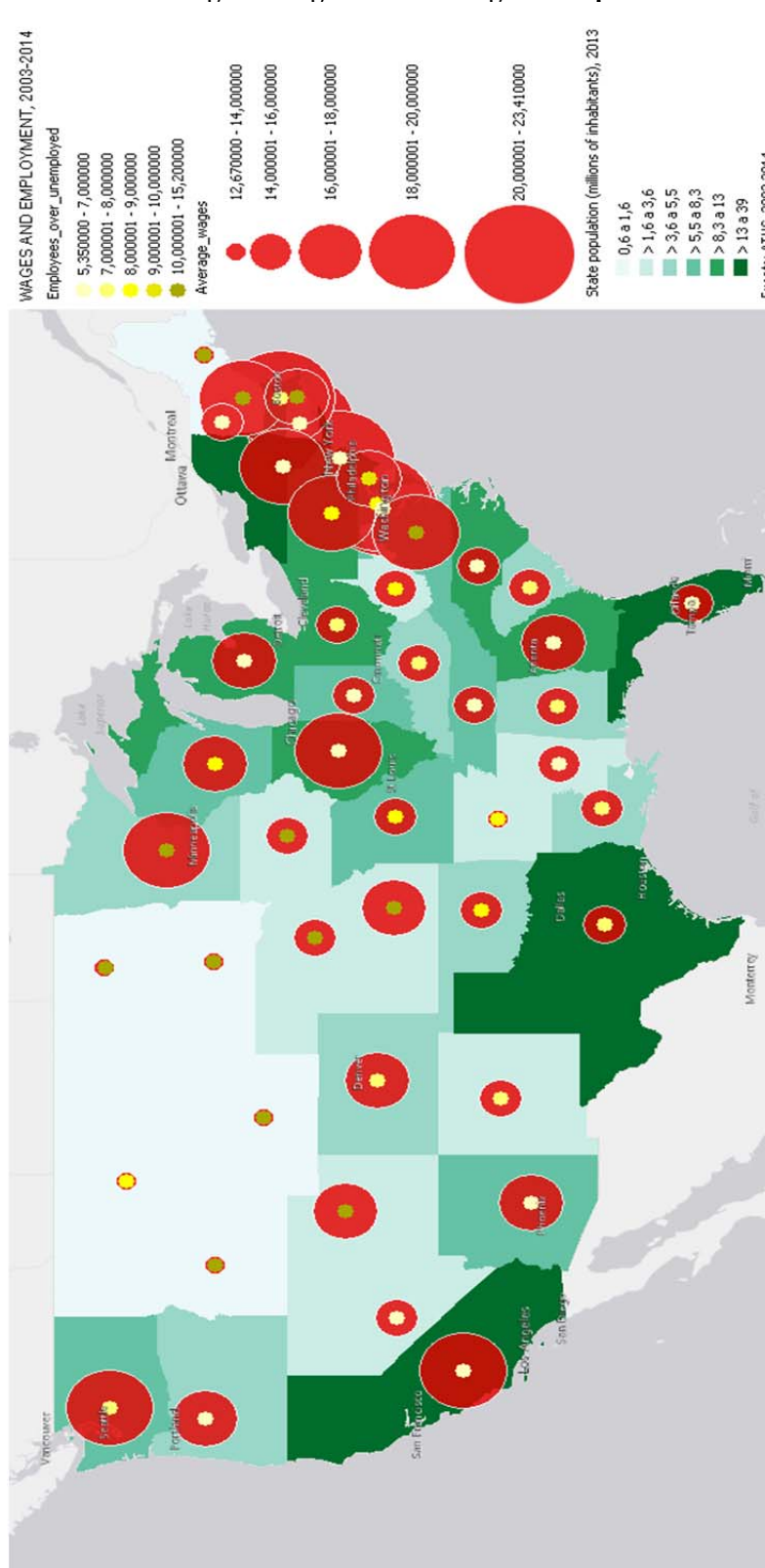
Note: The sample (ATUS 2003-2014) is restricted to employees and unemployed individuals..

Figure 4
Employment vs. commuting GIS map



Note: The sample (ATUS 2003-2014) is restricted to employees. Commuting time is measured in minutes per day.

Figure 5
Wage earnings vs. commuting GIS map



Note: The sample (ATUS 2003-2014) is restricted to employees. Average hourly earnings is measured in Dollars per hour, deflated using the deflator of the Federal Reserve, Bank of St. Louis.

Table 1
Summary Statistics of Variables

	Employees		Unemployed		p-values
	Mean	SD	Mean	SD	
Commuting time	38.005	40.615	-	-	-
Expected commuting	25.524	6.345	25.482	6.394	(0.526)
Hourly earnings	19.475	18.125	-	-	-
Males	0.509	0.500	0.454	0.498	(<0.01)
Age	42.196	11.322	39.205	13.225	(<0.01)
Years in labor market	20.815	11.465	19.275	12.704	(<0.01)
Primary education	0.071	0.256	0.192	0.394	(<0.01)
Secondary education	0.265	0.441	0.340	0.474	(<0.01)
University education	0.664	0.472	0.468	0.499	(<0.01)
Living in couple	0.608	0.488	0.461	0.499	(<0.01)
Partner's labor force status	0.459	0.498	0.333	0.471	(<0.01)
Number of children	0.971	1.126	1.091	1.223	(<0.01)
Naturalized citizen	0.913	0.282	0.889	0.315	(<0.01)
White	0.817	0.387	0.714	0.452	(<0.01)
American	0.838	0.369	0.820	0.385	(<0.01)
Father is American	0.800	0.369	0.762	0.426	(<0.01)
Mother is American	0.799	0.401	0.764	0.424	(<0.01)
Minimum wage	7.409	2.227	7.434	2.295	(<0.01)
M.S.A. population size	3.625	2.540	3.774	2.562	(<0.01)
Metropolitan (Center)	0.232	0.422	0.282	0.450	(<0.01)
Metropolitan (Balanced)	0.616	0.486	0.572	0.495	(<0.01)
Non-metropolitan	0.152	0.359	0.146	0.353	(0.257)
N. Observations	40,648		5,651		

Note: Standard deviations in parentheses. The sample (ATUS 2003-2014) is restricted to employees who work the diary-day and to unemployed individuals. Commuting time is measured in minutes. Employed group collects salaried workers in both public and private sectors. Monetary variables are measured in Dollars. Minimum wage (by State of residence) is taken from Wikipedia. Gender takes the value 1 for men and 0 for women. Occupation, Industry, States and MSAs statistical summaries are not shown in this table. P-values for the differences (Kruskal-Wallis test) are in parentheses.

Table 2
Estimates of employment models

Employment probability	(1) All	(2) Private sector	(3) Public sector
Expected commuting time	-0.013*** (0.003)	-0.010*** (0.003)	-0.032*** (0.004)
Years working	0.046*** (0.004)	0.040*** (0.005)	0.064*** (0.006)
Year working squared	-0.008*** (0.001)	-0.008*** (0.001)	-0.009*** (0.001)
Secondary education	0.662*** (0.049)	0.641*** (0.047)	1.166*** (0.097)
University education	1.271*** (0.049)	1.116*** (0.046)	2.402*** (0.092)
White	0.463*** (0.036)	0.527*** (0.034)	0.089* (0.050)
American	-0.171*** (0.061)	-0.215*** (0.059)	0.108 (0.080)
Living in couple	0.399*** (0.049)	0.397*** (0.049)	0.381*** (0.066)
Couple status	0.056 (0.049)	0.034 (0.047)	0.257*** (0.065)
N. of children	-0.111*** (0.014)	-0.109*** (0.014)	-0.096*** (0.022)
Naturalized Citizen	0.036 (0.072)	-0.004 (0.073)	0.685*** (0.112)
Male	0.291*** (0.042)	0.315*** (0.041)	0.149*** (0.052)
Constant	0.415*** (0.103)	0.350*** (0.099)	-2.718*** (0.167)
N. Observations	46,299	39,011	12,939

Note: Bootstrapped (n=500) standard errors in parentheses. The sample (ATUS 2003-2014) is restricted to employees who work the diary-day and to unemployed individuals (Column 1), to private sector salaried workers and unemployed (Column 2), and to public sector salaried workers and unemployed (Column 3). Commuting times are measured in minutes. Monetary variables are measured in Dollars. Gender takes the value 1 for men and 0 for women. * Significant at the 90% level. ** Significant at the 95% level. *** Significant at the 99% level.

Table 3
Estimates of earning models

Real hourly wages	(1) Private sector	(2) Private sector supervised	(3) Private sector not supervised	(4) Public sector
Expected commuting time	0.010*** (0.001)	0.011*** (0.002)	0.009*** (0.002)	0.007** (0.003)
Years working	0.034*** (0.002)	0.034*** (0.002)	0.036*** (0.003)	0.037*** (0.004)
Year working squared	-0.006*** (0.000)	-0.007*** (0.000)	-0.007*** (0.001)	-0.007*** (0.001)
Secondary education	0.248*** (0.021)	0.231*** (0.029)	0.247*** (0.029)	0.379*** (0.085)
University education	0.438*** (0.022)	0.485*** (0.029)	0.363*** (0.030)	0.643*** (0.085)
White	0.116*** (0.014)	0.115*** (0.018)	0.128*** (0.022)	0.035 (0.026)
American	0.004 (0.019)	-0.017 (0.027)	0.044 (0.032)	-0.050 (0.040)
Living in couple	0.103*** (0.016)	0.110*** (0.022)	0.079*** (0.025)	0.060* (0.033)
Couple status	-0.004 (0.015)	-0.017 (0.020)	0.021 (0.022)	0.005 (0.030)
N. of children	-0.018*** (0.005)	-0.016** (0.006)	-0.019** (0.008)	-0.011 (0.011)
Naturalized Citizen	0.068*** (0.024)	0.037 (0.033)	0.112*** (0.037)	0.129* (0.074)
Male	0.103*** (0.016)	0.085*** (0.021)	0.127*** (0.025)	0.102*** (0.034)
Constant	1.356*** (0.096)	1.148*** (0.129)	0.842*** (0.076)	1.021*** (0.322)
Occupation fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
N. Observations	33,360	21,467	11,893	7,288
R-squared	0.183	0.202	0.121	0.126

Note: Bootstrapped (n=500) standard errors in parentheses. The sample (ATUS 2003-2014) is restricted to private sector salaried employees (Column 1), supervised employees (Column 2), non-supervised employees (Column 3) and public sector employees (Column 4). Commuting time is measured in minutes per day. Real wages are measured in Dollars * Significant at the 90% level. ** Significant at the 95% level. *** Significant at the 99% level.

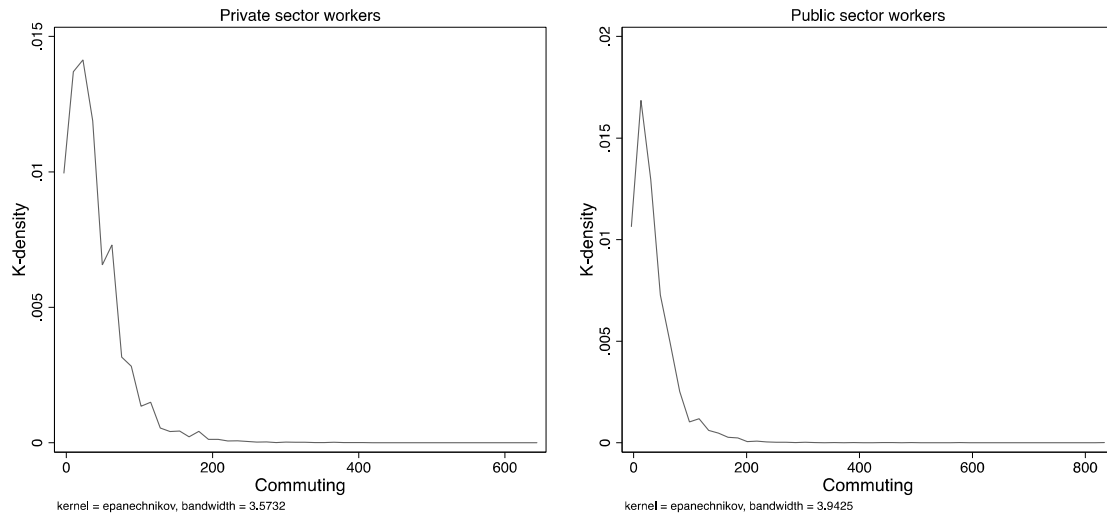
APPENDIX

Table A1
Heckman model of commuting time

	(1)	(2)	(3)
VARIABLES	Commuting	Employment	
MSA population size	1.962*** (0.115)		
Metropolitan (balanced)	3.326*** (0.566)		
Non-metropolitan	3.212*** (0.950)		
Female	-8.157*** (0.445)		
White	-2.724*** (0.586)		
American		-0.218*** (0.042)	
Naturalized Citizen		0.158*** (0.037)	
Father U.S.		0.149*** (0.041)	
Mother U.S.		0.070 (0.043)	
Min. wage		0.001 (0.003)	
Lambda			54.243*** (12.435)
Constant	22.105*** (3.021)	1.026*** (0.036)	
Observations	46,299	46,299	46,299

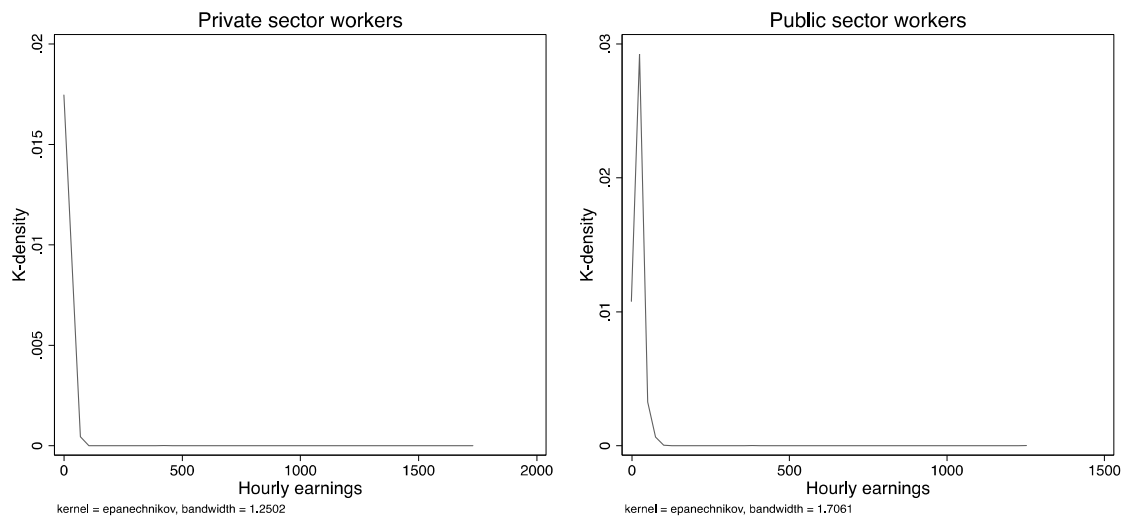
Note: Robust standard errors in parentheses. The sample (ATUS 2003-2014) is restricted to employed individuals, including the self-employed. Commuting time is measured in minutes. Female takes the value 1 for women and 0 for men. * Significant at the 90% level. ** Significant at the 95% level. *** Significant at the 99% level.

Figure A1
Densities of commuting time, by labor status



Note: The sample (ATUS 2003-2014) is restricted to employees. Commuting time is measured in minutes per day.

Figure A2
Densities of earnings, by labor status



Note: The sample (ATUS 2003-2014) is restricted to employees. Hourly earnings are measured in Dollars per hour.