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Jose Ignacio Gimenez-Nadal
Jose Alberto Molina
Jorge Velilla

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Jose Ignacio Gimenez-Nadal
University of Zaragoza

Jose Alberto Molina
University of Zaragoza and IZA

Jorge Velilla
University of Zaragoza

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

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ABSTRACT

A Wage-Efficiency Spatial Model for US Self-Employed Workers*

In this paper, we study self-employment in a theoretical setting derived from wage-efficiency spatial models, where leisure and effort at work are complementary. We develop a spatial model of self-employment in which effort at work and commuting are negatively related, and thus the probability of self-employment decreases with "expected" commuting time. We use time-use data from the American Time Use Survey 2003-2014 to analyze the spatial distribution of self-employment across metropolitan areas in the US, focusing on the relationship between commuting time and the probability of self-employment. Our empirical results show that the probability of self-employment is negatively related to the "expected" commuting time, giving empirical support to our theoretical model. Furthermore, we propose a GIS model to show that commuting and self-employment rates are, in relation to unemployment rates, negatively related.

JEL Classification: J21, J22, R12, R41

Keywords: wage-efficiency, self-employment, commuting, leisure, American Time Use Survey

Corresponding author:

J. Ignacio Gimenez Nadal
Department of Economic Analysis
Faculty of Economics and Business
University of Zaragoza
C/ Gran Via 2
50005 Zaragoza
Spain
E-mail: ngimenez@unizar.es

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1. Introduction

In this paper, we analyze the relationship between self-employment and commuting, within a framework based on urban wage-efficiency theory. According to wage-efficiency models, employed workers may receive a higher wage than the wage of the labor market equilibrium, in order to discourage or forestall shirking. The distribution of commuting and wealth in cities has been studied, but the focus has been on wage earners (Brueckner, Thisse and Zenou, 1997; Zax and Kain, 1991; Kain, 1968, Brueckner and Zenou, 2003; Gobillon, Selod and Zenou , 2007; Ross and Zenou, 2006) and self-employed workers have been largely overlooked.[1] Although analyses of employment and earnings, and their spatial distribution and commuting are common (see Ma and Banister, 2006, for a chronological review of commuting contributions), the relationship between self-employment and commuting has only rarely been studied (van Ommeren and van der Straaten, 2008; Gimenez-Nadal, Molina and Velilla, 2015).

We go a step further and include a spatial pattern to study the distribution of self-employment across cities, and where commuting plays an important role. Assuming that commuting and leisure time are substitutes (the more commuting time, the less time available for leisure), and that leisure time and effort at work (productivity) are complementary, we hypothesize that self-employed workers who devote comparatively less time to leisure will experience a decrease in their effort at work, and consequently they will not be as productive as they otherwise could be. Under these circumstances, we theoretically obtain that more time in commuting is negatively related to the probability of self-employment, as self-employment outcomes depend on a self-employment production function, apart from the "entrepreneurial spirit" (Cueto, Mayor and Suarez, 2015).

Against this background, the main goals of this paper are twofold. First, we develop a new analytical model of self-employment with a spatial pattern, in which "expected" commuting time is directly related to the probability of self-employment. Second, we empirically check results derived from the model. We characterize self-employment by a production function with temporal, capital, and personal inputs, and also entrepreneurial spirit and individual expectations (Blau, 1985; Taiwo, 2011; Cueto, Mayor and Suarez, 2015; Dawson *et* al., 2015). The main results derived from the model are that the self-

[1] The relationship between commuting and income has also been analyzed in Manning (2003), White (1999) and Zax (1991).

employed locate close to the places where it is possible to fund a business, and that the relationship between commuting and self-employment outcomes depends on aspects of commuting, leisure, and housing across the city. The differentiation of self-employment and commuting in a model comes from significant commuting differences, as prior research has shown that the self-employed devote less time to commuting, due to different search conditions in the labor market (van Ommeren and van der Straaten, 2008; Gimenez-Nadal, Molina and Velilla, 2015). But despite these differences, the basic idea of substitutability between leisure and shirking can be extended to self-employed individuals without loss of generality. This last, and the absence of theoretical spatial models of self-employment, have motivated this paper.

We use the American Time Use Survey, ATUS, for the years 2003-2014, which includes information on commuting time, leisure, labor force status, and other individual characteristics, to develop our self-employment spatial empirical model. We find that, on average, “expected” commuting time is negatively related to self-employment, as obtained from our theoretical framework. This relationship is consistent with spatial wage-efficiency theory and with the hypothesis of Ross and Zenou (2006) about substitutability between leisure and shirking. Furthermore, we use ATUS data to propose a GIS model for employment. Our map shows that the rate of self-employment is higher in low-population states, which also present shorter commuting times.

We develop a theoretical model through which we analyze the spatial distribution of self-employment and self-employment outcomes, by developing a theoretical model of self-employment where productivity, commuting, leisure, and entrepreneurial spirit are of major importance. To the best of our knowledge, prior research has not focused on this issue. Second, we use time use data from the US to test the adequacy of our theoretical model. Time use databases have been underused in this field, although the ATUS has been previously used in commuting analyses offering positive and consistent results (Gimenez-Nadal, Molina and Velilla, 2015). Our empirical results show that self-employment has a negative relationship with “expected” commuting time, indicating that self-employment is located close to places where economic activity is concentrated, and that shirking and leisure are substitutes in the case of self-employed workers. Furthermore, we make use of GIS modelling, a powerful and tool, useful for showing spatial information according to its geographic position, in the form of a map.

The rest of the paper is organized as follows. In Section 2, we propose our spatial model for the self-employed. Section 3 describes our data, and Section 4 presents our empirical results. Section 5 contains our GIS model, and Section 6 lays out our main conclusions.

2. A new spatial model for self-employment

The aim of this Section is to apply urban wage-efficiency theory to a self-employment background. In doing so, we assume that self-employed workers are not paid a wage by an employer, but receive income from their own business. Blau (1985) and Taiwo (2011) develop a model where self-employment is determined by a production function whose elements are capital investment, time, and personal (managerial and technical) abilities. In this framework, we assume productivity (i.e., effort at work) affects the production function that measures self-employment outcomes. Furthermore, Cueto, Mayor and Suarez (2015) argue that the "entrepreneurial spirit" of individuals determines self-employment, and Dawson *et* al. (2015) show the power of being realistic or optimistic in self-employment outcomes. The latter is consistent with Ahn (2010), who shows that risk-tolerance is an important determinant of the decision to enter self-employment. Thus, the entrepreneurial spirit of the self-employed, their expectations, and the interaction of both elements also play a key role in our theoretical model.

We develop a model for self-employment decisions (i.e., being self-employed, or not) against a background where some of the main hypotheses are taken from urban wage-efficiency theory (where *wage* must be understood as self-employment income) with urban/spatial components, and with location of business and residence, commuting, leisure, effort at work, individual expectations and entrepreneurial spirit having primary importance. In our context, the main difference from the urban wage-efficiency model is that we cannot talk about high *wages* to compensate for commuting (and leisure loss) and to discourage shirking, because self-employment income depends directly on effort; besides, there is no external supervision in self-employment, which also plays a major role in urban wage-efficiency models.

We consider a population (normalized to 1) in a linear city (with length also normalized to 1). At one extreme of the city ($x = 0$) we locate the city center, x_c, and at the other extreme ($x = 1$) we locate the city fringe, x_f. We consider that the city is completely centralized, i.e., all the vacant places where a new business can be settled are in x_c. An opposite scenario can be posed, when all the vacant places are located in the city fringe (a completely decentralized city). Although the main concept refers to the distance between home and job, location of housing is not a negligible concept, due to heterogeneous living costs, as we will define below. Our economy will have only one kind of resident: those who have an own business, or can aspire to one (the unemployed who may wish to become entrepreneurs). We exclude salaried workers, and the unemployed who do not wish to become entrepreneurs. Under this assumption, individuals in our model will have two possible states: being self-employed or being unemployed. An important conceptual difference from the urban wage-efficiency models is that individuals are no longer fired from their jobs< rather, they decide when to stop working and become unemployed, according to their income and their entrepreneurial spirit. This decision depends on the expectations of self-employment, $\bar{I}$, which we take to be homogeneous and exogenous.

Following Ross and Zenou (2006), we consider individuals who do not have the entrepreneurial spirit, and if they are unemployed they decide to fund a new business according to a Markov process with transition rate $\theta > 0$. In other words, after an exponential random time of parameter θ, an unemployed individual starts a new business and leaves unemployment to become an entrepreneur (self-employed). Then, the expected time an individual will be unemployed until he or she starts a business (analogous to finding a job in an urban wage-efficiency context) is $1/\theta$. On the one hand, individuals decide to leave self-employment and become unemployed when their business does not succeed, i.e., when their expectations are higher than the value of their utility. We assume that the probability of not succeeding, for those individuals, is modeled by a Markov process with transition rate $\delta > 0$. Then, the expected time of being self-employed until business comes to an end is $1/\delta$. Under these assumptions, and Markov process transition rates, we obtain the expected fraction of a lifetime that an individual in our economy will be self-employed, $\frac{\theta}{\delta+\theta}$, and unemployed (i.e., unemployment rate), $\frac{\delta}{\delta+\theta}$. Furthermore, this unemployment rate in the equilibrium can be redefined as the probability that an individual in our economy will be unemployed, which coincides with the proportion of his/her lifetime in unemployment, i.e., $u_{ns} = \frac{\delta}{\delta+\theta}$. We assume that there is a fraction N_{ns} of individuals who do not have the entrepreneurial spirit.

In another scenario, individuals who have entrepreneurial spirit decide to leave self-employment, and become unemployed, when they achieve half of their expectations or less. This is modeled by a Markov process with transition rate $\delta/2 > 0$. Then, the expected time of being self-employed until business ends is $2/\delta$. Under these assumptions, and Markov process transition rates, we obtain the expected fraction of a lifetime that an entrepreneurial individual in our economy will be self-employed, $\frac{2\theta}{\delta+2\theta}$, and unemployed, $\frac{\delta}{\delta+2\theta}$. Furthermore, this unemployment rate in the equilibrium can be redefined as the probability that an entrepreneurial individual in our economy will be unemployed, which coincides with the unemployed proportion of his/her lifetime, i.e., $u_s = \frac{\delta}{\delta+2\theta}$ (see Note 1 of the Appendix for this development). We assume that there is a fraction of entrepreneurial individuals N_s, subject to $N_s + N_{ns} = 1$.

The self-employment outcome is characterized by a production function $F \equiv F(t, k, p)$ where *t* is the temporal input, *k* is the capital investment input, and *p* is a parameter that denotes personal capabilities (Blau, 1985; Taiwo, 2011). Although *t* may vary substantially across individuals, we consider it is exogenous and fixed. If we do not do this, the model will have endogeneity problems between commuting and leisure times. We also take *k* as a constant in order to focus on the effect of *p*. We will denote $F_i = F(t, k, p_i)$.

We next define the utility functions of individuals. For the self-employed, the instant utility is defined as $c_{se} + V_{se}(l_i)$, where c_{se} is consumption (whose price is unitary) and *l* is leisure time. The temporal budget for these individuals is given by $1 - t = l_i + Tx_i$, where the total available time is normalized to 1, and the monetary constraint is given by $F_i = R(x_i) + R_h(0) + \tau x_i + c_{se}$. T is the (constant) parameter that determines the relationship between commuting distance and time, $R(.)$ measures housing costs, and $R_h(.)$ determines the rental costs of the business locations. In the model, rental prices are homogeneous because all the business locations are in x_c, so $R_h(0) = R_h$ constant (we do not consider variation of prices across locations) and we can normalize $R_h = 0$. For the unemployed, the instant utility is defined as $V_u + c_u$ constant, where c_{se} is consumption (whose price is unitary) and the constraint is the monetary constraint, $b = c_u + R(x_i)$; b is the unemployment benefit, which is a constant normalized to 0. In employmewnt models, commuting costs are also included for the unemployed in order to measure the job-search costs; however, to the extent that vacancies to establish a business are easier to find than employment vacancies (van Ommeren and van der Straaten, 2008; Gimenez-Nadal, Molina and Velilla, 2015), we assume that the search is costless in our model.

With these instant utilities, we can define indirect utilities for both the self-employed and the unemployed, respectively:

$$I_{se}(x_i, p_i) = V_{se}(l_i) + c_s = V_{se}(1 - t - Tx_i) + F_i - R(x_i) - \tau x,$$

$$I_u(x_i) = V_u + c_u = V_u - R(x_i).$$

Within this framework, we define the expected utility of individuals over their life cycle, which must be equal for every individual in the equilibrium, I_{eq}. We assume perfect capital markets (zero interest rate). Also, we consider fixed places of residence. This hypothesis is commom in urban models (e.g. van Ommeren and van der Straaten, 2008; Gimenez-Nadal, Molina and Velilla, 2015; Ross and Zenou, 2003, 2006; Zenou, 2006), although some authors impose the opposite (Wasmer and Zenou, 2002). The logic behind this assumption is the high cost of moving.

Life-cycle utilities vary across individuals with entrepreneurial (I_s) and without entrepreneurial (I_{ns}) spirit, as follows:

$$I_s = P(\text{being self employed})I_{se} + P(\text{being unemployed})I_u = u_s I_u + (1 - u_s)I_{se} =$$

$$= u_s(V_u - R(x_i)) + (1 - u_s)(V_{se}(1 - t - Tx_i) + F_i - R(x_i) - \tau x) =$$

$$= u_s V_u + (1 - u_s)(V_{se}(1 - t - Tx_i) + F_i - \tau x) - R(x_i).$$

$$I_{ns} = P(\text{being self employed})I_{se} + P(\text{being unemployed})I_u = u_{ns} I_u + (1 - u_{ns})I_{se} =$$

$$= u_{ns}(V_u - R(x_i)) + (1 - u_{ns})(V_{se}(1 - t - Tx_i) + F_i - R(x_i) - \tau x) =$$

$$= u_{\square s} V_u + (1 - u_{ns})(V_{se}(1 - t - Tx_i) + F_i - \tau x) - R(x_i).$$

We now focus on the characteristics and capabilities of individuals, p. Blau (1985) and Taiwo (2011) consider that this parameter represents the technical and managerial abilities of individuals, although in general it is not empirically confirmed (Molina et al., 2015). Hence, we introduce p as the level of effort at work. We assume that individuals with entrepreneurial spirit make a greater effort because they enjoy their work and they will be more productive than individuals without entrepreneurial spirit, who may have established their own business due to necessity. In this context, values of p for the vocational individuals characterizes them as being more productive than individuals without entrepreneurial spirit, who are, by definition, less productive and tend to shirk more ($p_s > p_{ns}$).

In our model, shirking plays a conceptually important role. Urban wage-efficiency theory argues that more commuting leades to less leisure; furthermore, leisure and shirking at work can be seen as substitutive concepts, so workers who do not have much leisure time at home will be less productive (they will shirk at work) than those who have more leisure time. As leisure is what provides utility to individuals, if an individual presents longer commuting times, then leisure time will be affected and so will the klevel of effort at work. We can summarize this as follows: distance from home to work, x, affects commuting time, Tx, which affects leisure time at home, l (as far as t is fixed), which affects effort at work, p.

Henceforth, we cannot follow efficiency-wage models since, in our current framework, wage increases cannot be used to encourage effort at work. Rather, as a first step, we study the spatial pattern of distribution of individuals in the equilibrium across our lineal city, on the decision of entrepreneur (to become self-employed) or remain unemployed. We define x_0 as the city location that separates entrepreneurial spirit and non-entrepreneurial spirit individuals in the equilibrium. We want to know which group will be located in $[x_c, x_0)$ and which in $(x_0, x_f]$. We make use of the bid-rent functions, which are a normal issue in urban models, and represent the maximum hiring price, depending on distance and utility, that individuals are willing to pay in the equilibrium. We must differentiate between the bid-rents of individuals with and without entrepreneurial spirit, as follows:

$$\psi_j(x, p_j) = u_j V_u + (1 - u_j)\big(V_{se}(1 - t - Tx) + F(p_j) - \tau x\big) - I_{eq}, \quad j = s, ns.$$

We note that $\psi_s(x_0, p_s) = \psi_{ns}(x_0, p_{ns})$ by definition of bid-rents and x_0 . Furthermore, it is easy to check that $\partial\psi_j(x, p_j)/\partial x < 0$ for $j = s, ns$ (see Proposition 1 of Appendix A), so to determine the location pattern we must determine which bid-rent has a steeper slope. If one group $j = 1$ has a bid rent with a slope in x_0 steeper than the other, $j = 2$, then the former will be able to pay more for living in $[x_c, x_0)$ and will be located there, and the latter will be located in $(x_0, x_f]$ (see Figure 1 of Appendix A for a schematic of this example).

By evaluating bid-rents for individuals with and without entrepreneurial spirit, we obtain that $|\partial\psi_s/\partial x| > |\partial\psi_{ns}/\partial x|$ always, and particularly in x_0, so individuals with entrepreneurial spirit (i.e., productively self-employed) will be located near the city center and individuals without entrepreneurial spirit (i.e., shirking self-employed) will be located in the outskirts of the city (see Proposition 2 in Appendix).

Now, making $\psi_{ns}(x_0, p_{ns}) = \psi_s(x_0, p_s)$, we can obtain the following expression that determines x_0:

$$V_{se}(1 - t - Tx_0) - \tau x_0 = V_u - \frac{(1 - u_{ns})F(p_{ns}) - (1 - u_s)F(p_s)}{u_s - u_{ns}}.$$

This expression allows us to determine how x_0 varies with increases or decreases in *F*. By differentiating the previous expression by *F*, and assuming that $F(p_{ns})$ and $F(p_s)$ changes in the same proportion (i.e., $\partial F(p_{ns})/\partial F = \partial F(p_s)/\partial F = 1$) we obtain that $\partial x_0/\partial F > 0$ (see Proposition 3 in Appendix). This means that if the number of self-employed people increases in general (by external shocks, by capital investment increases, by temporal investment increases, by laws that favor entrepreneurs…), then there will be more individuals with entrepreneurial spirit among the population. It follows that, if there is a possibility to increase earnings from self-employment, then individuals will have incentives to be efficient workers in their business. The opposite matters too: if there is a generalized decrease in *F*, then the number of entrepreneurial spirit individuals will decrease.

The variation of x_0 when *p* varies is obvious, since entrepreneurial spirit determines both elements. If there is more entrepreneurial spirit among the population, then *p* and x_0 increase. On the other hand, if there is less entrepreneurial spirit (there are more individuals without entrepreneurial spirit), *p* and x_0 decrease.

Finally, the variation of F when x varies (i.e., the relationship between self-employment outcomes and commuting) is not clear. If we differentiate $\bar{I}$ by *x* we obtain that:

$$\frac{\partial F}{\partial x} = \frac{R'(x)}{1 - u_i} + T\frac{\partial V_{se}}{\partial x} + \tau.$$

In this setting, $R'(x) < 0$ because living costs decrease with distance from the city center, and $1 - u_i > 0$ for both *s* and *ns*. On the other hand, $T\partial V_{se}/\partial x + \tau > 0$. Then, the sign of $\partial F/\partial x$ depends on variations of living costs, leisure utility, and commuting costs. If variations of living costs are greater (smaller) than variations of commuting costs and leisure utility, then $\partial F/\partial x < 0$ ($\partial F/\partial x > 0$) and living further (closer) from the city center implies lower (higher) self-employment earnings. This result is conceptually evident from the model and the equilibrium. Assuming that every individual has the same life-cycle utility in the equilibrium, and those who live further from the city center have more (less) net benefit derived from living costs, leisure, and commuting, then earnings (which in our context are exclusively derived from self-employment) must be lower (higher) than those of others who live near the city center.

3. Data and variables

We use the American Time Use Survey (ATUS) from the years 2003-2014 to analyze the relationship between self-employment 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 certain personal, familiar, 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 questions 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. Figure 1 shows the evolution of self-employment and unemployment rates in the US, using ATUS, and we observe that the evolutions of self-employment and unemployment follow opposite directions: self-employment has decreased while unemployment has increased over the period, in line with Blanchflower (2000). One reason could be that commuting time for the self-employed has increased, which affects shirking, and thus self-employment success via effort at work. Under these circumstances, the proportion of the unemployed willing to be entrepreneurs has decreased, as they may have a longer "expected" commute.

In order to test the model, we further restrict the sample to individuals who are unemployed or self-employed, and to working days in the case of self-employed workers, defined as those days where individuals spend more than 60 minutes working. We restrict the sample of self-employed workers to working days to avoid computing zero minutes of commuting to any self-employed worker who filled out the time-use diary on Saturday, Sunday, or a holiday, which would affect our computation of "expected" commuting. These restrictions leave us with 11,267 individuals, of which 5,651 are unemployed and 5,623 are self-employed. Also, 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 at home)". Figure 2 shows the average commuting time (in minutes per day) for the self-employed workers in our sample, and we observe that average commuting time has increased, which is consistent with the decrease and increase in self-employment and unemployment rates, respectively. Additionally, the reported increase in commuting time is in line with Kirby and LeSage (2009) and Gimenez-Nadal and Molina (2014).

One important issue is that our model relates commuting time to the probability of self-employment, comparing unemployed and self-employed workers. However, the problem here is that commuting time is not observed for the unemployed, and that reported (i.e., real) commuting time may differ from the "expected" commuting time of the self-employed. Furthermore, using reported commuting time for the self-employed may lead to endogeneity problems. Here we follow Ross and Zenou (2006) and predict commuting time for both the unemployed and the self-employed. In doing so, we use the Heckman (1979) technique and we estimate a Heckman's two-step two-equation model where, in one of the equation (participation equation), we estimate the probability of being self-employed vs. being unemployed, and in the second we estimate the time devoted to commuting, controlling by sample selection of being self-employed.

For the 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, 2005; 2009: Fernandez, 2007; 2011). According to this literature, differences in cultural origin may affect labor force participation decisions, and thus, to identify participation into self-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 but was born elsewhere (Naturalized Citizen), if the father was born in the US (Father US), and if 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 (BLS, 2013), which may affect their commuting time. Additionally, we follow Ross and Zenou (2006) and include variables measuring 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 simply 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 data about the size of the area of residence. The ATUS includes information on the population size of the metropolitan area in which a household is located, that is coded as follows: 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 B1 of Appendix B shows the results of estimating a two-step Heckman model of commuting, with selection into participation in self-employment. We observe that being American is negatively related to the fact of being self-employed, in comparison to the unemployed; this may be due to unemployed non-Americans who later return to their home countries. Being a naturalized citizen is positively related to being self-employed, as is having an American father. However, mother's nationality is not related to self-employment. In the case of commuting time, we observe that the size of the MSA has a positive relationship with the time devoted to commuting, that the location of residence

(.e., metropolitan vs. non-metropolitan) also matters, and that female individuals have comparatively less commuting time than males. 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 (self-employed vs. unemployed). We also show *p*-values of the non-parametric Kruskal-Wallis test.[2] We show the average and standard deviation of the original commuting of the self-employed (i.e., "Current commuting time"), and the average and standard deviation of the variable defined as "Expected commuting" that is predicted from the Heckman model. We observe that the self-employed devote, on average, 28.9 minutes to daily commuting, and their coefficient of variance is 1.50, considering reported commuting times. Figure 3 shows the k-density of commuting time for the self-employed. We can see how zero and low commuting times concentrate the mass. In the case of "Expected commuting", we obtain 4.93 and 3.71 daily minutes on average for the self-employed and the unemployed, respectively. Because these are expected values, standard deviations and variance coefficients decrease considerably, and we observe that the average "Expected commuting" is longer for the self-employed in comparison with the unemployed.

We have defined other variables that may affect self-employment, such as gender (male), age, *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 citizen, being white, and being American. For education we consider three levels: "basic education" (less than high school diploma), "secondary education" (high school diploma) and "university education" (more than high school diploma). We have also included the years in the labor market squared to measure non-linear effects. According to Table 1, there are more male self-employed than female (63.8% vs. 36.2%) and there are more female unemployed (54.6%, vs. 45.4% of males). The self-employed are older than the unemployed (46.3 vs. 39.2 years on average) and also have had more years in the labor market (24.6 vs. 19.3 years on average). This relationship is consistent with Blanchflower (2000) and Molina et al. (2015), who found

[2] Results for *t*-test comparison are available on request; although the *t*-test is designed for normal distributions, the Kruskal-Wallis test offers a more accurate comparison in our case.

that age is positively related to the fact of being an entrepreneur. For educational variables, we observe that 5% of the self-employed have only basic education, 24% have secondary education, and 71% have University education, versus 19%, 34% and 47% of the unemployed, respectively. Thus, we find that a University education seems to be positively related to self-employment. Regarding the family variables, we show that 71% (46%) of the self-employed (unemployed) live in couple, 54% (33%) have a couple who both work and they have 1.024 (1.090) children on average. Furthermore, 93% (89%) are naturalized citizens, 89% (71%) are white, and 86% (82%) are Americans.

4. Econometric analysis

In this Section, we analyze the probability of being self-employed, compared to being unemployed, with a focus on the expected commuting time of individuals. To that end, we estimate a logit model where, for a given individual i, SE_i is the dummy variable "self-employed" that takes value "1" if i is a self-employed worker, and value "0" if i is unemployed. By hypothesis, *SE* follows a binomial distribution, $SE_i \sim B(p_i, n_i)$. Then, C_i represents the expected commuting time of individual i, $\boldsymbol{Y}_i$ includes a set of socio-demographic variables, and ε_i represents random variables capturing unmeasured factors and measurement errors. We estimate:

$$\text{logit}(SE_i) = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 C_i + \boldsymbol{\beta}_2 \boldsymbol{Y}_i + \varepsilon_i,$$

where the logit function is directly related to the probability of being self-employed. Thus, if a parameter estimation is positive (negative), we interpret it as follows: when the corresponding independent variables increase, the logit function of being self-employed increases (decreases), and thus the probability of being self-employed increases. The set of socio-demographic variables includes 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 (i.e., 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 on the probability of being self-employed, i.e., $\beta_1 < 0$.

Furthermore, since we are using generated regressors in the logit model, 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 produce 500 replications of the model where a random sample with replacement is drawn from the total number of observations. We also include MSA fixed effects, which represent the metropolitan area in which a household is located.[3] However, to the extent that this regional variable may be highly correlated with expected commuting, we also estimate the logit model without including MSA fixed effects.

Table 2 shows the results of estimating Equation (1) on the probability of being self-employed. Column (1) presents the results including MSA fixed effects, while Column (2) presents the results without MSA fixed effects. We observe that expected commuting is negatively related to the probability of being self-employed, with this relationship being statistically significant at the 99% confidence level, with and without MSA fixed effects. Thus, our theoretical modeling is robust according to our empirical evidence, which is also consistent with the self-employed concentrating near the places where it is possible to fund a business. In fact, the latter relationship does not depend on whether we control for MSA differences, i.e., on the inclusion of MSA fixed effects in the empirical model. Experience, measured as years working, is negative and quadratically related to self-employment, drawing a "U" shape. Educational level is positively related to self-employment activity. If we control by basic educational level, the more education (secondary education and university education), the greater the probability of being self-employed. Whites also have a higher probability of being self-employed, while being a naturalized citizen and being American are not related to self-employment. Males have a higher probability of being self-employed than women. Regarding the family attributes, living in couple, couple's labor status, and number of children are positively related to self-employment.

Thus, our empirical results for self-employment give empirical support, in the case of United States, to our theoretical model. Self-employment has a negative relationship with expected commuting, which results in self-employed workers locating close to the city centers, according to our theoretical framework. More generally, the self-employed tend to live nearer the places where jobs are located, relative to the unemployed, and thus

[3] Metropolitan areas are counties or groups of counties centering on a substantial urban area. While 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. Metropolitan areas often cross state lines. Information on the coding of this variable con be found in https://www.atusdata.org/atus-action/variables/METAREA#description_section

we offer empirical support for the main hypothesis of complementarity of leisure and efficiency at work (or productivity) of our model.

5. GIS model

We now develop a graphical analysis of self-employment and commuting, making use of Geographical Information System (GIS) models. (This tool is mainly used in the field of Geography.) GIS consists of representing or projecting certain characteristics over an Earth map, using data on latitude and longitude to obtain illustrative, descriptive information with a clear spatial trend. GIS is not a common tool in economics; it has been especially used in small samples whose individuals are located in the same city, where there exists a lot of urban information about individuals (Kwan and Kotsev, 2015).

As far as we have information of the state of residence of each individual in our sample, we represent for each State the average commute of the workers and the rate of self-employed workers over unemployed individuals. Thus, we show a map of the US with averaged information about individuals at the state level. Making use of ATUS 2003-2014, and from a map of the US, we include the geographical location of each State, its population size (taken from the US Census Bureau), the average commute of the individuals living there, and the rate of the self-employed over the unemployed. GIS cannot be used to draw inferences, but for showing descriptive results. However, due to the implicit spatial setting of the tool itself, and to the spatial pattern of our analysis, we think that the results obtained are illustrative and useful. Our purpose is to check whether, in areas with high average commuting, the self-employed over the unemployed rate is larger or smaller.

Figure 4 shows the average commuting time by State, in relation to the self-employed over unemployed rate, and to each State's population. We find that, in general, the highly-populated states (also with the most crowded cities), with the highest average commute times, also present the smallest rates of self-employed over unemployed individuals. This result is consistent with our model, as highly-populated areas present the highest average commute times, and these high-commuting areas present a lower probability (i.e., ratio of self-employed/unemployed) of being self-employed. On the other hand, in low-populated states (north-mid and north-west of the country) there are high proportions of self-employed individuals over unemployed, and also comparatively shorter commuting times. Again, this result is consistent with our model, as low-populated areas present comparatively short average commutes, and they also present comparatively greater probabilities (i.e., ratio of self-employed/unemployed) of being self-employed.

We can assume that, first, highly-populated cities (e.g., East Coast states, California, Texas) concentrate a large number of public sector workers, because of institutions and Universities. Second, big firms are also, normally, located in big capital cities and so many salaried workers will live there. Third, in these big cities, it could be more difficult to start an own business, due to crowding, high hiring prices, or competition; on the other hand, in smaller cities, the self-employed can benefit from lower living costs and hiring prices, and with reduced potential rivalry. Furthermore, we must consider that self-employment is a labor alternative to being unemployed when someone cannot find, or does not want to find, an employer. To the extent that self-employment and entrepreneurship arises from desire, innovation, vocation, and necessity, and while firms are concentrated in populated areas and capitals, individuals who do not live in big cities will tend to be entrepreneurs and will become self-employed more due to necessity (those individuals who become self-employed because they cannot find an employer), contributing to a higher rate of self-employed over unemployed.

We can conclude from our map modeling that commuting is negatively related to the proportion of self-employed over unemployed via population. In other words, more populated states, where commuting times tend to be longer, concentrate many firms and institutions and individuals do not tend to become self-employed because there is a greater demand for lbor, which decreases entrepreneurship arising from necessity. Less populated areas, that present shorter commuting times, have higher self-employed over unemployed rates because self-employment could be a more attractive labor status, due to there being fewer salaried opportunities.

6. Conclusions

This paper analyzes self-employment in a context derived from urban wage-efficiency theory with a spatial pattern. We propose a new theoretical model for self-employment, indexed by commuting and efficiency at work, and we find that, although vocational and productive individuals will tend to live near their work-places, commuting does not have a clear relationship with earnings, and it depends on leisure value and housing and living costs variations within cities. Making use of the ATUS for the years 2003-2014, we present a self-employment empirical micro-econometric model. Our empirical results show that commuting is negatively related to self-employment. We find evidence for our theoretical modeling and, in particular, for the hypothesis about leisure and shirking at work being substitutable.

Our GIS mapping shows that the rate of self-employed over unemployed tends to be higher in states with smaller average commuting times, which are also the less populated states. This could be due to firms and institutions being concentrated in more populated areas, with self-employment being an attractive labor status (due to necessity) in less-populated areas.

Our results contribute to the literature by not only complementing urban wage-efficiency models in a self-employment setting, but also offering a new theoretical study of self-employment in the United States with a spatial pattern. We also give empirical support to our new model. Furthermore, we use time-use data to analyze the US labor market, which has been underappreciated in this field. Finally, we use GIS modeling to analyze the US labor market, a useful tool for spatial analysis that is underused, but offers intuitive and illustrative results.

However, our analydoes have certain limitations: by using cross-sectional data, we cannot find causal effects. Furthermore, unobservable heterogeneity also has a strong impact on our self-employment empirical modeling, where non-controllable variables, such us innovation, entrepreneurial spirit, and financial situation could determine self-employment, and also institutions and legal treatment (evasion rates, taxes; see Torrini, 2005). Finally, we do not have data about self-employment earnings, and we cannot analyze their relationship with commuting times. More research on this topic is needed.

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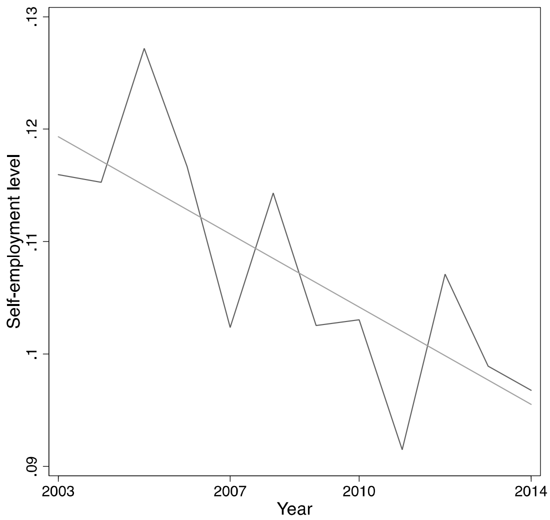
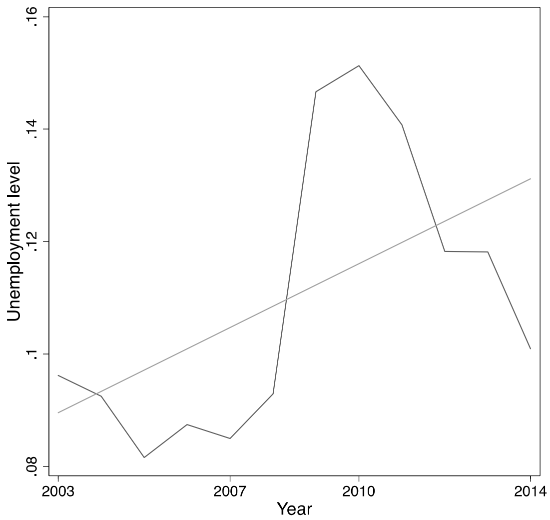
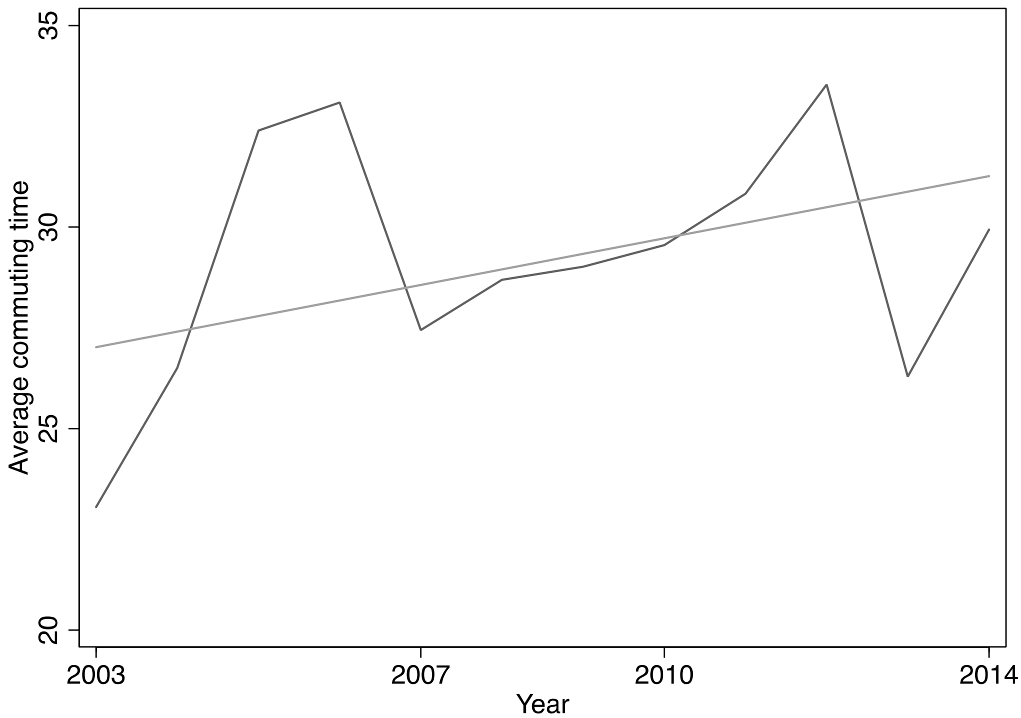
Figure 1
Evolution of self-employment and unemployment





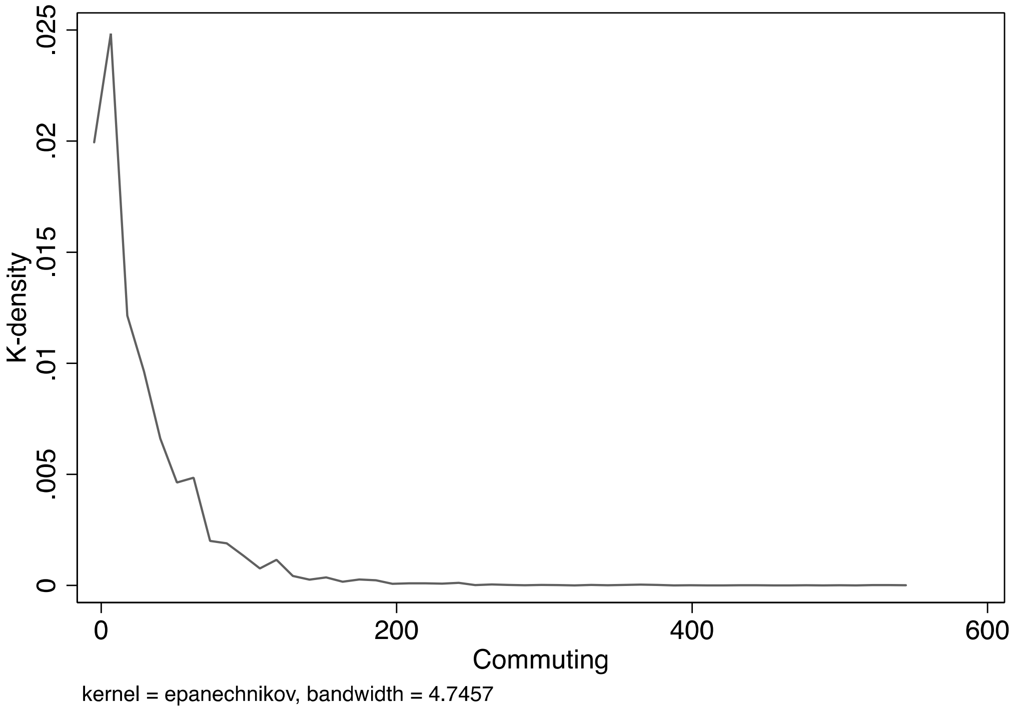
Note: The sample (ATUS 2003-2014) is restricted to self-employed or unemployed individuals. Levels are measured in points per unit.

Figure 2
Evolution of commuting time, self-employed workers in the ATUS



Note: The sample (ATUS 2003-2014) is restricted to self-employed workers. Average commuting time is measured in minutes.

Figure 3
Density of commuting time



Note: The sample (ATUS 2003-2014) is restricted to self-employed individuals. Commuting time is measured in minutes.

Figure 4
GIS map

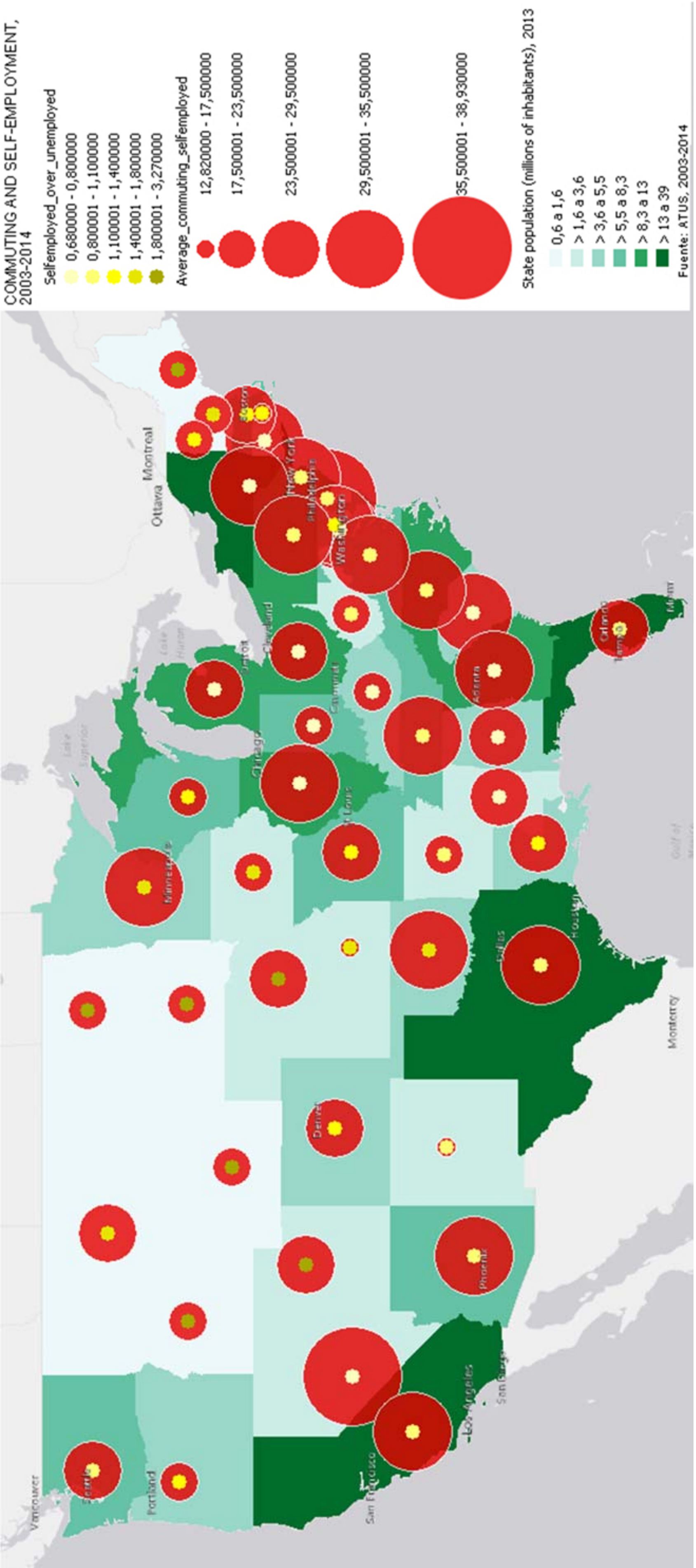


Table 1
Sum Stats of variables

	Self-employed		**Unemployed**		
Variables	Mean	SD	Mean	SD	*p*-values
Current Commuting time	28.890	43.411	-	-	-
Expected Commuting	4.928	4.707	3.709	4.638	(<0.001)
Male	0.638	0.481	0.454	0.498	(<0.001)
Age	46.304	10.381	39.205	13.225	(<0.01)
Years in labor market	24.584	10.513	19.275	12.704	(<0.01)
Years in labor market sq.	71.486	52.012	53.289	54.184	(<0.01)
Basic education	0.054	0.226	0.192	0.394	(<0.01)
Secondary education	0.237	0.426	0.340	0.474	(<0.01)
University education	0.709	0.454	0.468	0.499	(<0.01)
Living in couple	0.706	0.456	0.461	0.499	(<0.01)
Partner's labor force status	0.537	0.499	0.333	0.471	(<0.01)
N. of children	1.024	1.207	1.091	1.223	(0.015)
Naturalized citizen	0.933	0.250	0.889	0.315	(<0.01)
White	0.889	0.314	0.714	0.452	(<0.01)
American	0.859	0.351	0.820	0.385	(<0.01)
N. Observations	5,623		5,651		

Note: Standard deviations in parentheses. The sample (ATUS 2003-2014) is restricted to self-employed who work the diary-day and to unemployed individuals, between the ages of 15 and 65 who are not retired nor students. Commuting time is measured in minutes per day. Monetary variables are measured in Dollars. 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 self-employment models

	(1)	(2)
Expected commuting	-0.019***	-0.024***
	(0.006)	(0.004)
Years working	0.101***	0.099***
	(0.007)	(0.007)
Year working squared	-0.014***	-0.014***
	(0.002)	(0.002)
Secondary education	0.706***	0.696***
	(0.082)	(0.084)
University education	1.567***	1.547***
	(0.083)	(0.084)
White	0.899***	0.885***
	(0.063)	(0.059)
American	-0.077	-0.092
	(0.090)	(0.089)
Living in couple	0.472***	0.472***
	(0.065)	(0.065)
Couple status	0.302***	0.305***
	(0.063)	(0.064)
N. of children	0.045**	0.044**
	(0.020)	(0.021)
Naturalized Citizen	0.166	0.162
	(0.121)	(0.112)
Gender	0.924***	0.959***
	(0.063)	(0.059)
Constant	-3.810***	-3.679***
	(0.172)	(0.163)
MSA fix effects	Yes	No
Observations	11,267	11,274

Note: Bootstrapped standard errors in parentheses. We have computed 500 separate bootstrapped estimations. The sample (ATUS 2003-2014) is restricted to self-employed who work during the diary-day and to unemployed individuals, between the ages of 15 and 65 who are not retired nor students. Commuting times are measured in minutes per day. Monetary variables are measured in Dollars. * Significant at the 90% level. ** Significant at the 95% level. *** Significant at the 99% level.

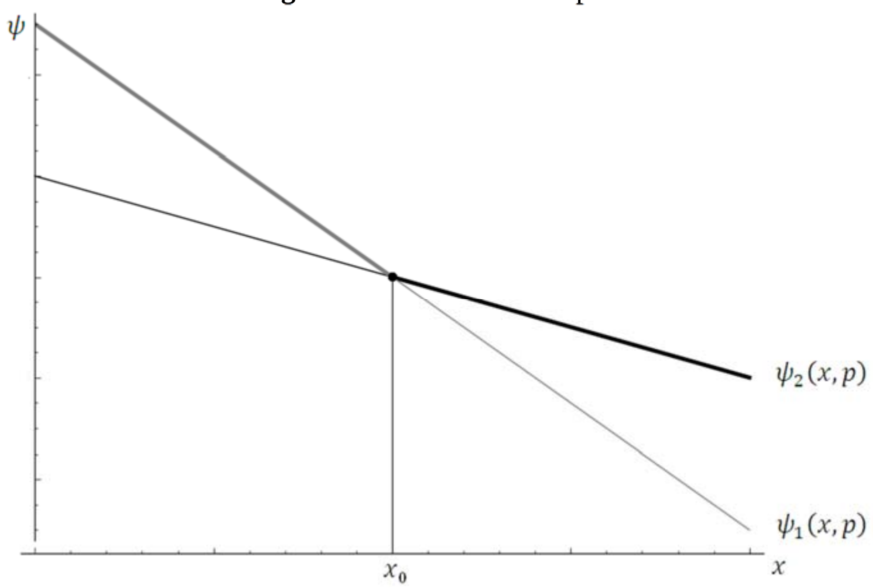
APPENDIX A

Note 1. For individuals without entrepreneurial spirit, a *mean cycle* is equal to $\frac{1}{\delta}+\frac{1}{\theta}$, which repeats over time. So the proportion of time in the life-cycle that an individual is self-employed or unemployed is the same as this proportion of time over one mean cycle; the proportion of time in a cycle that an individual is unemployed is $\frac{1/\theta}{1/\theta+1/\delta}=\frac{\delta}{\delta+\theta}$, and the one that is employed is $\frac{1/\delta}{1/\theta+1/\delta}=\frac{\theta}{\delta+\theta}$. For individuals with entrepreneurial spirit, this is analogous, but a *mean cycle* is equal to $\frac{2}{\delta}+\frac{1}{\theta}$, so the respective proportions are $\frac{1/\theta}{1/\theta+2/\delta}=\frac{\delta}{\delta+2\theta}\left(<\frac{\delta}{\delta+\theta}\right)$ and $\frac{2/\delta}{1/\theta+2/\delta}=\frac{2\theta}{\delta+2\theta}\left(>\frac{\theta}{\delta+\theta}\right)$.

Proposition 1. $\partial\psi_j(x,p_j)/\partial x<0$ for $j=s,ns$.

Dem: substituting $\psi_j(x,p_j)=u_jV_u+(1-u_j)(V_{se}(1-t-Tx)+F(p_j)-\tau x)-I_{eq}$ and differentiating by x, we obtain that $\partial\psi_j(x,p_j)/\partial x=(1-u_j)(-T\,\partial V_{se}/\partial l\,-\tau)$. As $u_j\in[0,1]$ and $T,\tau>0$, $\partial\psi_j(x,p_j)/\partial x>0\ \Leftrightarrow\ \partial V_{se}/\partial l\,>0$, which is obvious because leisure is by hypothesis what provides utility to individuals.

Figure A1. Bid-rents example



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Proposition 2. $|\partial\psi_s/\partial x| > |\partial\psi_{ns}/\partial x|$ always.

Dem: For $j = s, ns$, $|\partial\psi_j/\partial x| = -\partial\psi_j/\partial x = (1-u_j)(T\,\partial V_{se}/\partial l + \tau)$; $T\partial V_{se}/\partial l + \tau$ is common for $j = s$ and ns, and by definition $1 - u_{ns} < 1 - u_s \Rightarrow -\partial\psi_s/\partial x > \partial\psi_{ns}/\partial x$ always.

Proposition 3. $\partial x_0/\partial F > 0$ if $\partial F(p_{ns})/\partial F = \partial F(p_s)/\partial F = 1$.

Dem: Differentiating the expression that determines x_0 by F and assuming the hypothesis, we obtain:$\partial V_{se}/\partial l\ \partial l/\partial x|_{x_0}\partial x_0/\partial F - \tau\partial x_0/\partial F = -\frac{(1-u_{ns})-(1-u_s)}{u_s-u_{ns}} = -1$. Taking into account that $\partial V_{se}/\partial l > 0$ and $\partial l/\partial x|_{x_0} = -T$, then the result follows.

APPENDIX B

Table B1
Heckman prediction for commuting time

	(1)	(2)	(3)
VARIABLES	**Commuting**	**Self-employment**	
MSA population size	1.054***	-	
	(0.302)	-	
Metropolitan (balanced)	3.564**	-	
	(1.540)	-	
Non-metropolitan	-0.118	-	
	(2.438)	-	
Female	-12.652***	-	
	(1.187)	-	
White	-0.853	-	
	(1.850)	-	
American	-	-0.293***	
	-	(0.067)	
Naturalized Citizen	-	0.351***	
	-	(0.060)	
Father U.S.	-	0.247***	
	-	(0.065)	
Mother U.S.	-	0.058	
	-	(0.067)	
lambda	-	-	32.411***
	-	-	(8.740)
Constant	2.657	-0.319***	
	(7.520)	(0.040)	
Observations	11,274	11,274	11,274

Note: Standard errors in parentheses. The sample (ATUS 2003-2014) is restricted to all employed individuals, including wage employees. 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.