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Carole Brunet, Thierry Kamionka, Guy Lacroix

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CREST
Center for Research in Economics and Statistics
UMR 9194

5 Avenue Henry Le Chatelier
TSA 96642
91764 Palaiseau Cedex
FRANCE

Phone: +33 (0)1 70 26 67 00
Email: info@crest.science
https://crest.science/

Home Ownership, Labour Market Transitions and Earnings☆

Carole Brunet[a], Thierry Kamionka[b], Guy Lacroix[c]

[a] *Department of Economics, Université Paris 8, France.*
[b] *CNRS and CREST, Paris, France.*
[c] *Department of Economics, Université Laval, Canada.*

Abstract

The paper investigates the links between home ownership, employment and earnings. The motivation stems from the lack of consensus in the literature linking these outcomes. Our analysis is cast within a dynamic setting and the endogeneity of each outcome is assessed through the estimation of a flexible panel multivariate model with random effects. The data we use are drawn from the French sample of the *EU Survey on Income and Living Conditions* for the years 2004–2013. Our results show that while homeowners have longer employment and unemployment spells, they must contend with lower earnings than tenants upon reemployment. Importantly, our results highlight the importance of distinguishing between outright and indebted home owners. Indeed, the latter are found to behave more or less like tenants on the labour market. At the aggregate level, thus, the positive relationship between home ownership and unemployment rate, known as Oswald's conjecture, might thus depend on the share of leveraged homeowners in the population.

Key words: Home Ownership, Unemployment, Earnings, Heterogeneity, Simulation based estimation, Panel data.

JEL-codes: J21, J64, J31, C33, C35

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Email addresses: `carole.brunet@univ-paris8.fr` (Carole Brunet), `kamionka@ensae.fr` (Thierry Kamionka), `Guy.Lacroix@ecn.ulaval.ca` (Guy Lacroix)

1. Introduction

Approximately 70% of European households were homeowners on 2014 (INSEE, 2016). Homeownership varies from as little as 52.5% in Germany to as much as 90.3% in Slovakia. The United Kingdom (64.8%) and France (57.6%) are intermediate-lower cases, while Mediterranean countries such as Italy (73.2%) and Spain (78.8%) exhibit intermediate to high rates. The United Stated (63.5%, U.S. census 2016) would also qualify as an intermediate case by European standards. Some have argued that such heterogeneity may partly reflect cultural differences (Huber and Schmidt, 2022). Others claim that it may stem from a wide array of programs and public policies that have been implemented over the years to foster access to homeownership (Andrews and Sanchez, 2011). Programs such as subsidised loans, zero interest loans, lower down payments rules, tax deductible mortgage interest payments, *etc.* are now widespread. In France, zero interest loans ("Prêts à Taux Zéro"), tax deductible interest payments and property tax abatement on the main residence were all designed to that end.

The rationale for favouring homeownership is manifold (Havet and Penot, 2010; Andrews and Sanchez, 2011). Positive externalities in the form of increased health and fertility, lower crime rates, and increased community involvement are often associated with higher rates of homeownership (see, e.g. Dietz and Haurin, 2003; DiPasquale and Glaeser, 1999; Glaeser and Sacerdote, 2000, for a summary of the literature). Haurin, Parcel and Haurin (2002) also underline the existence of a positive correlation between homeownership and children test scores, though such a correlation may simply reflect a better environment and geographic stability or the impact of some omitted heterogeneity. Experimental evidence (Engelhardt et al., 2010) provides somewhat mixed results when trying to account for unobserved individual characteristics favoring both homeownership and the provision of social capital and local amenities.

Yet, another strand of the literature has emphasised the potentially deleterious effects of homeownership on the labour market. What is now conventionally referred to as "Oswald's hypothesis" or "Oswald's conjecture" suggests that homeownership and unemployment are positively related Indeed, Oswald (1996) suggested that the high unemployment rates observed in OECD countries at the beginning of the nineties were due to increased homeownership. In his original paper, he concluded that a 10 percentage points increase in homeownership was associated with a 2 percentage points increase in the unemployment rate. Oswald (1997) additionally suggested that the differences in the unemployment rates across industrialised countries were mainly the consequence of the differences in the levels of homeownership. Finally, he also argued (Oswald,

1999) that reducing homeownership through more efficient rental markets would contribute to reducing the unemployment rates in Europe. The positive relationship between homeownership and unemployment at the aggregate level is mainly explained by homeowners' lesser mobility: Because they would incur greater mobility costs, they are more at risk of becoming unemployed should the local labour market face an economic downturn, and are also more likely to experiment longer unemployment spells and poorer matches while employed. In addition, different types of externalities could strengthen these direct effects of homeownership on the labor market: "not-in-my-backyard" behaviors (Oswald, 1999; Blanchflower and Oswald, 2013); increasing commuting and traffic congestion costs; consumption effects due to mortgage substitution (Laamanen, 2017).

Oswald's conjecture was based upon aggregate data on the labour and housing markets of OECD countries (Oswald, 1996, 1997). Several studies have replicated Oswald's analyses using more recent data on other regions or countries. On the whole, they tend to confirm his conjecture: The positive link between homeownership and unemployment holds across US states (Blanchflower and Oswald, 2013; Coulson and Fisher, 2009; Green and Hendershott, 2001), in Germany (Lerbs, 2011; Wolf and Caruana-Galizia, 2015), and in Finland (Laamanen, 2017). One exception is France where the converse seems to hold (Sari, 2015).

It has been acknowledged that the results based upon aggregate data might reflect composition effects or fail to consider important confounding factors. This is why many have turned to individual data to investigate the issue. Yet, the main difficulty with such data arises from the potential endogeneity between homeownership and outcomes of interest. Indeed, individuals who self-select into homeownership may have unobserved characteristics that jointly affect the outcome variables (employment probability, wage rate, duration of unemployment spells, reemployment wage, labour market mobility, *etc.*). The recent literature thus considers models of unemployment duration with self-selection into homeownership and unobserved heterogeneity in an attempt to account for potential econometric biases. Interestingly, this literature yields mixed results. Thus, while homeowners are found to have shorter unemployment duration than renters in Denmark (Munch et al., 2006) and France (Brunet et al., 2012), the latter are either found to last longer in the UK and the US (Morescalchi (2016, UK), Guler and Taskin (2018, US)) or to be no different (Battu et al. (2008, UK), Brunet et al. (2012, US), Caliendo et al. (2015, US), Vuuren (2017, Netherlands)).

Another strand of the literature has focused on employment spells. Home-ownership has been found to reduce inflows into unemployment in the US and in several European countries (Barrios García, 2017; de Graaff and van Leuvensteijn, 2013; Coulson and Fisher, 2009; Munch et al., 2008; Battu et al., 2008). Still others have focused on the relationship between homeownership and wages. According to some (Coulson and Fisher, 2002; Caliendo et al., 2015; Munch et al., 2008), homeowners earn higher wages than renters. Yet Coulson and Fisher (2009) conclude the opposite while Guler and Taskin (2018) and Yang (2019) find that the former have lower reemployment wages than the latter.

Most of the aforementioned papers focus on single employment/unemployment spells. In order to reconcile the somewhat contradictory empirical findings, the interdependencies between housing status, labour market status and wage rates must be properly accounted for. In particular, all three outcomes are intrinsically dynamic and exhibit substantial inertia: past outcomes are good predictors of current ones (Employment: Heckman and Borjas (1980); Cappellari and Jenkins (2008); Duhautois et al. (2018). Wages: Hospido (2015). Housing: Kan (2000)). While the relevant literature has devoted much attention to the unobserved heterogeneity issue, the dynamic nature of the processes at stake has often been overlooked, or given minimal consideration.[1] This raises the issue of distinguishing path dependency from unobserved heterogeneity (Heckman, 1981b). In this paper we jointly model home-ownership, employment and earnings within a dynamic framework so as to distinguish between true and spurious state dependence. Our analysis distinguishes between outright homeowners and mortgagors since latter have been found to search more intensively (Morescalchi, 2016; Flatau et al., 2003; Brunet et al., 2007; Baert et al., 2014). The model incorporates unobserved heterogeneity to control for self-selection in all three equations. The individual random effects are allowed to be correlated across equations, just as are the idiosyncratic error terms. In addition, the latter are also allowed to be autocorrelated. Finally, since we observe many transitions both on the labour and housing markets, we model the past selection mechanisms that led to the initial status appropriately.

The model is estimated using the French sample of the EU-SILC panel dataset for the period ranging from 2004 to 2013. Our results are consistent with previous findings (e.g., Munch et al., 2008) insofar as homeowners are found to enjoy longer employment spells and higher earnings. Interestingly, it is also found that outright homeowners experience longer unemployment spells than tenants and earn less than previously upon reemployment. On the other hand, it is also found

[1] As noted by (Blanchflower and Oswald, 2013, p.18), "High levels of home-ownership do not destroy jobs this year; they tend to do so, on our estimates, the year after next. Unless these long linkages are studied, the consequences of high levels of home-ownership are not easy to see."

that mortgagors and tenants behave similarly.

Contrary to the previous literature, our results are robust to the negative selection into unemployment and to the endogeneity of housing tenure. They contribute to the understanding of the interplay between labour and housing markets by putting forward the role of the mortgage market: financial constraints borne by leveraged homeowners might counteract deterrent inertia effects induced by homeownership. At the aggregate level, the relationship between homeownership and unemployment rate might thus depend on the share of homeowners with on-going mortgages.

This result adds to previous findings from simulated or calibrated models found in the literature which have overlooked the role of mortgage constraints. In particular, Beugnot et al. (2018) conclude from various simulations of an equilibrium labour market model à la Pissarides that homeownership is detrimental to aggregate labour market performances only when mobility costs are high (due to ill-designed housing market regulation for example). The relationship between homeownership and unemployment rates is reversed if mobility costs are lowered somehow. Furthermore, in an equilibrium model that is calibrated on both US and European data, Head and Lloyd-Ellis (2012) find that the effect of homeownership on the unemployment rate is quite small. Indeed, A 10% reduction in the homeownership rate is associated with a reduction of unemployment of only one-third (two-thirds) of a percentage in the US (Europe). This is because homeownership has a significant impact in their model only when both the unemployment and the mobility rates are high, a highly improbable configuration. Our own results shed light on the role of mortgage debt on homeownership effects on the labour market, and in particular how mortgage debt affects mobility under different institutional environments (Johnston et al., 2021).

Interestingly, our overall estimated homeownership effect on the reemployment probability and wages is negative, indicating that the "outright effect" dominates the "mortgage effect" in France for the years 2004-2013. We relate this result to the declining share of mortgagers during this time period, and document other features of the housing market. Our findings also raise questions at the cross-road between cultural norms and the economic system, including fiscal and inheritance policies. In France, both cultural and fiscal institutions tend to support housing transmission from parents to children, whereas the US system leads to a much more liquid view of housing as an asset. At low levels of homeownership in the economy, increasing homeownership entails a large share of mortgagers, and a negative relationship with aggregate unemployment. At higher levels of homeownership, the relationship with unemployment might rest upon the underlying share of mortgagers. Of course, mortgage and credit system pose their own sustainability challenge, as the 2008 sub-prime crisis has demonstrated.

According to our results, thus, Oswalds' conjecture appears to be valid in situations where the proportion of outright homeowners is large. In situations were they are few, increasing the share of homeowners (outright or mortgagors) is unlikely to impact the unemployment rate.

The outline of the paper is as follows. We provide an overview of French housing and labour markets and describe our data in section 2. The econometric model is presented in section 3. The estimation results are presented in section 4. The last section concludes.

2. French Housing and Labour Markets: Overview and Sample Description

Our empirical analysis focuses on the French labour and housing markets. In what follows, we briefly describe their main features. Next, we discuss the data and the survey from which they are drawn.

2.1. Overview of the French Housing and Labour Markets

Approximately 56% of French households were home-owners between 2004–2014, our sample period. This proportion is somewhat lower than the European average at 70% (INSEE, 2016). While the proportion of home-owners has remained fairly constant through time, its composition has not (Séverine et al., 2015). As shown in Figure 1(a), the share of outright homeowners was 36.2% in 2004 and amounted to 40.7% in 2014. Over the same period, the share of mortgagors declined from 20.4% to 17.1% while the proportion of tenants remained fairly stable at approximately 39%.

In France, culture and fiscal arrangements favour ownership transmission between parents and children through inheritance, family contribution and preferred tax treatment. Yet, for many, home-ownership is achieved by means of a standard housing loan. Hence, loan terms, housing prices, and the labour market status of household members are core determinants of home-ownership. Figure 1(b) depicts the evolution of mortgage interest rates and housing prices over our sample period. As shown, the interest rate has decreased by nearly two percentage points, save for the 2005-2008 period during which it increased by one percentage point.[2] Starting in 2008, the interest rates have decreased steadily until 2015 by as much as three percentage points from their peak of 5.7%. As expected, housing prices and interest rates are more or less inversely related,

[2]The figure plots the "Taux effectif des prêts immobiliers à taux fixes accordés aux particuliers" of the Banque de France.

save for the period between 2006–2008 during which both were increasing.[3] Housing prices have increased by as much as 35% between the first quarter of 2004 and their peak value in 2012. As shown in Figure 2, the mean monthly duration of mortgage loans increased by over 19.9% (from 196 months to 235 months) and was closely linked to the fluctuations in the interest rate. The fluctuations on the housing market occurred while the labour market was relatively depressed as the unemployment rate ranged between 7.4% to 10.2% over the same period.

Mobility is intimately related to the housing status. In 2013, for instance, among all households who had moved at least once during the past four years, 8.2% where homeowners, 20.8% were tenants in subsidized housing, and 48.5% were regular tenants (Delance and Vignolles, 2017). Average housing tenure was 27.2 years for outright homeowners, 7.5 years for mortgagors, 13.0 years for tenants in subsidized housing, and only 5.7 for regular tenants (Séverine et al., 2015). During a typical year, as many as 819,000 transactions are recorded which represents approximately 2.37% of the entire housing stock (Arnold, 2016).

Housing mobility in France is more or less halfway between that of Northern Europe (Sweden, Finland, Norway) and the USA, but higher than Germany and Great Britain, and certainly higher than Southern Europe (Spain and Italy) or countries such as Poland and Slovakia (Andrews and Sanchez, 2011). In 2014, as many as 7.3 million individuals, representing 11% of the entire population, moved into a new dwelling. For the same year, 74% of all moves took place within the same region, and of those, 38.2% were within the same city (Levy and Dzikowski, 2017).

The labour market in France is also "average" by European standards. Thus while the unemployment rate reached 9.4% in 2017, it was as low as 3.8% in Germany, 4.2% in Norway and 4.3% in the UK, but as high as 11.2% in Italy and 17.2% in Spain. The relatively dynamic French housing market coupled with a relatively high, but fluctuating, unemployment rate provides an adequate environment to investigate the relationship between ownership status, earnings and unemployment.

2.2. The Data

Our data are drawn from the French sample of the EU-SILC data set (European Union - Status on Income and Living Conditions). The French survey itself is based upon *L'enquête statistique sur les ressources et conditions de vie* (Dispositif SRCV) and is conducted from May to June every

[3]Housing prices are drawn from "Indice des prix des logements anciens en France métropolitaine", Ensemble, Base 100 au premier trimestre de 2010, Série CVS, Insee.

year since 2004. We restrict our sample window to the 2004–2013 period to insure a balanced coverage of the 2008 financial crisis. Over 9,091 households (26,353 individuals) were surveyed in 2004 and as many as 11,131 in 2013 (26,353 individuals).

The SRCV is a rotating panel. Each year since 2005, approximately 1/9 of all households are replaced by an incoming group drawn from the list of all dwellings located in mainland France. Thus approximately 1/9 of those surveyed in 2004 were still in the panel in 2012. By virtue of its rotating design, the SRCV yields an unbalanced panel. Yet, it is representative of all the regular households living in metropolitan France and contains detailed information on income, living conditions, employment and ownership statuses, wealth, *etc.* While all individuals over sixteen years of age are surveyed, we restrict our sample to those between 20 and 56 since they are those most concerned with employment and housing decisions. This exclusion restriction yields a sample of over 30,077 individuals, and all are observed for at least two consecutive years.

Table 1 presents the main characteristics of the sample. The first column reports the descriptive statistics for the initial sample at entry (*i.e.* in 2004). Column (2) focuses on the characteristics of the incoming groups while columns (3)-(5) distinguishes them according to their housing status. As expected from a rotating design, the incoming cohorts and the original 2004 cohort are very similar. Indeed, the means of the three dependent variables reported in columns (1) and (2) are very close to one another. The rotating samples are slightly younger and also slightly more educated than the original cohort. Gender, urban location and citizenship are likewise well balanced across cohorts. Two features of the data are worth stressing. First, outright home-owners and mortgagors share many characteristics except for the fact that the latter are younger and more educated. Second, tenants are quite distinctive. They earn less, are less educated, they are much younger and fewer are married. Likewise, they are more likely to live in a large city and fewer are French natives.

The differences between home-owners and tenants on one hand, and between outright owners and mortgagors on the other hand, are likely to impact their responses to exogenous shocks on the housing and the labour markets. An increase in mortgage interest rates may prevent tenants from purchasing a property. It will also affect mortgagors when refinancing their loans depending on the balance and the term of their mortgage. Likewise, an economic downturn will likely have differentiated impacts according to individual housing and labour market statuses. Responses to exogenous shocks will also be sensitive to unobserved individual characteristics and housing/labour histories. The complex interdependencies between the two markets must be investigated in light of a dynamic econometric model.

3. Model Specification and Estimation

3.1. Model Specification

Consider a dynamic model that encompasses home-ownership (h), employment (e) and earnings (w). Let x_{jit}, $j \in \{h, e, w\}$, denote a vector of characteristics for individual $i = 1, \ldots n$, and where $t = 1, \ldots, T$ is a year index. Likewise, let β_j and δ_j be vectors of parameters associated with observed heterogeneity and past realisations of the endogenous variables ($\delta_{jk} \in I\!R$), respectively, for $j \in E = \{h, e, w\}$.

The latent dependent variable y^*_{jit} is given by

$$y^*_{jit} = x'_{jit}\,\beta_j + z_j(y_{it-1})'\,\delta_j + r_{jit}, \tag{1}$$

for any $j \in \{h, e\}$, where $z_j(\cdot)$ is a vector containing the realisations of the lagged individual outcomes. The observed values of the endogenous variables are denoted as $y_{it} = (y_{hit}, y_{eit}, y_{wit})' \in \{0, 1\} \times I\!R$.

For individual i at time t, the decision j, $j \in \{h, e\}$, is a binary variable that can be written as

$$y_{jit} = I\!I[y^*_{jit} > 0], \tag{2}$$

where $I\!I[.]$ is an indicator function equal to 1 if the event between brackets occurs and zero otherwise. The log of the yearly earnings at time t is

$$y_{wit} = x'_{wit}\,\beta_w + z_w(y_{it-1}, y_{hit})'\,\delta_w + r_{wit}, \tag{3}$$

where δ_w, β_w and $z_w(\cdot)$ are defined similarly as above, save for $z_w(\cdot)$ which also depends on the contemporaneous value of the ownership status.

3.2. Stochastic Specification

The error term, r_{jit}, is written as the sum of a time-invariant outcome-specific unobserved individual component, α_{ij}, and a contemporaneous residual, u_{jit}:

$$r_{jit} = \alpha_{ij} + u_{jit}. \tag{4}$$

As is customary, the individual effects, α_{ij}, are assumed to be independent of the observable characteristics, x_i, to be normally distributed with mean zero and variance $\sigma^2_{\alpha_j}$, $j \in E$, and to be independent across $i \in \{1, \ldots, n\}$ and $j \in \{h, e, w\}$. The contemporaneous error term is further assumed to satisfy the following independence assumptions: $u_{jit} \perp\!\!\!\perp x_i$, and $u_{jit} \perp\!\!\!\perp u_{j'i't'}$. On the other hand, u_{jit} is allowed to be autoregressive (but stationary, for $t > 0$).[4] Thus we write:

$$u_{jit} = \rho_j u_{jit-1} + \epsilon_{jit}, \tag{5}$$

where $\alpha_{ij} \perp\!\!\!\perp \epsilon_{j'it}$, for all $j, j' \in E$, and $\epsilon_{jit} \perp\!\!\!\perp u_{j'it'}$, for all $t' < t$ and $j' \in E$. The time-dependency allows to measure the impact of a shock at t on individual outcomes at $t + 1$.

In any dynamic panel data model with random effects and left censoring, the initial conditions much be appropriately accounted for. We follow Heckman (1981a) and write the initial conditions as a reduced-form specification which allows to correlate the error terms at $t = 0$ with those at $t > 0$. Thus let the system of equations at time t_0 be written as follows:

$$\begin{aligned}
y_{hi0} &= \mathbb{1}[x'_{hi0}\,\beta^0_h + r_{hi0} > 0], \\
y_{ei0} &= \mathbb{1}[x'_{ei0}\,\beta^0_e + r_{ei0} > 0], \\
y_{wi0} &= x'_{wi0}\,\beta^0_w + r_{wi0},
\end{aligned} \tag{6}$$

where x_{ji0} is the vector of initial characteristics and r_{ji0} is an error term similarly defined as above ($j \in E = \{h, e, w\}$). Likewise β^0_j is an appropriately dimensioned vector of parameters ($\beta^0_j \in \mathbb{R}^{p_j}$, where $p_j \in \mathbb{N}^*$corresponds to the dimension of β^0_j) . The initial error terms are assumed to satisfy the following two assumptions:

$$r_{ji0} \sim \mathrm{N}(0, \sigma^2_{j0}), \text{ where } j = h, e, w; \tag{7}$$

$$\epsilon_{jit} \sim \mathrm{N}(0, \sigma^2_{\epsilon_j}). \tag{8}$$

As argued by Heckman (1981a), it is likely that r_{ji0} is correlated with $r_{j'it}$, $j' \in E$, for $t = 1, \ldots, \mathrm{T}$. Hence, let $\rho_{\alpha_j \alpha_k}$ denote the correlation between the random effects α_{ij} and α_{ik}, specific to equations j and k, respectively, $j, k \in E$. Let ρ_{jk} denote the correlation between the idiosyncratic terms ϵ_{jit} and ϵ_{kit}, for all $t = 1, \ldots, T$ and $i \in \{1, \ldots, n\}$. For the two binary

[4] Hyslop (1999) makes a similar assumption in the context of a single equation model.

equations, y_{hit}^* and y_{eit}^*, this specification is equivalent to a dynamic probit model with random effects. Additional assumptions must be made to insure the model is identified. Indeed, because the two dependent variables are dichotomous we must normalize the variance of the corresponding residuals as follows:

$$\sigma_{\alpha_j}^2 + \sigma_{u_j}^2 = 1,$$

and

$$\text{var}(r_{ji0}) = \sigma_{j0}^2 = 1, \text{ for } j = h, e.$$

It can be shown that for $j \in E, t > 1$

$$\text{var}(u_{jit}) = \sigma_{u_j}^2 = \frac{\sigma_{\epsilon_j}^2}{(1-\rho_j^2)},$$

3.3. Model Estimation

For each individual and time period, we observe the realization of the variables $y_{jit} \in \{0; 1\}$, for $j = h, e$, as well as the log-earnings y_{wit} ($i = 1, \ldots, n$ and $t = 0, 1, \ldots, T$). The contribution of individual i to the likelihood function is [5] :

$$L_i(\theta) = \int_{A_i} \phi(r; \Omega)\, d\, r, \tag{9}$$

where $\phi(.; \Omega)$ is the probability density function of the normal distribution with mean zero and variance-covariance matrix Ω. The integration is computed over the error terms r that are compatible with the trajectories of the endogenous variables of individual i:

$$A_i = \left\{ r \in \mathbb{R}^{3(T+1)} : r = (r_{h0}, r_{e0}, r_{w0}, r_{h1}, ..., r_{hT}, ..., r_{w1}, ..., r_{wT}) \text{ and } a_{jit} \leq r_{jt} \leq b_{jit} \right\}.$$

The domain of integration depends on the realisations of the dependent variables, the vector of explanatory variables, and the vector of parameters, θ (see Appendix F). The latter can be estimated by maximising the logarithm of the simulated likelihood:

$$\hat{\ell}_{N,H}(\theta) = \sum_{i=1}^{N} \ln \left(\frac{1}{H} \sum_{h=1}^{H} \tilde{p}(x_i; u_i^h; \theta) \right), \tag{10}$$

[5]The order of integration is at most 30 since we have three state variables and ten periods, *i.e.* $j \in E = \{h, e, w\}$ and $t \in 2004 \ldots 2013$. The modelling of the initial conditions is reported in Appendix E for the sake of brevity

where the drawings u_i^h are specific to the individual i and are $i.i.d.$ $(i = 1, \ldots, n)$ (see Appendix G). These are drawn in such a way as to avoid rejection.[6] The main difficulty when making the draws is to account for the fact that the endogenous variables are both qualitative and continuous (Chang, 2009). The simulated maximum likelihood estimator of θ can be obtained maximizing the function (10). The SML estimator will be consistent and efficient as $\frac{\sqrt{N}}{H} \longrightarrow 0$ when $N \longrightarrow +\infty$ and $H \longrightarrow +\infty$ (cf., for instance, Gouriéroux and Monfort, 1991, 1993, 1997; Kamionka, 1998; Edon and Kamionka, 2008; Gilbert et al., 2011; Kamionka and Ngoc, 2016). In practice, the number of draws is set to $H = 30$. Several authors have stressed that the SML estimator is near consistent even for a relatively small H ($\approx$ 30).

4. Results

Our model includes three endogenous variables: ownership and employment statuses, equation (2), and earnings, equation (3). The stochastic specification is given by equations (4) and (5). The initial conditions in equation (6) are modelled according to the approach proposed by Wooldridge (2005).[7] To ease interpretation, the parameter estimates of each endogenous equation are reported in separate tables. Thus, Table 2 focuses on the ownership equation while Tables 3 and 4 focus on the employment and earnings equations, respectively.[8] Furthermore, each table is divided into three panels in which we report the slope parameters, the state dependence parameters, and the initial conditions parameters, respectively.

Tables 2–4 present three different specifications. Specification (1) is similar to empirical models customarily reported in the literature, albeit all three equations are estimated simultaneously and explicitly account for the contemporaneous endogeneity of the ownership status in the employment and the wage equations. We distinguish between outright homeowners (Owner(100%)) and mortgagors (Owners (<100%)). Note that the specification does not account for state dependence nor does it correct for the initial conditions problem. This is done in Specifications (2) and (3). The former now includes lagged ownership and employment statuses in all three equation. In addition, we also include an interaction term between the latter two in the employment and wage equations. We do this in order to investigate the differential impact of being an unemployed

[6] The term $\tilde{p}(x_i; u_i^h; \theta)$ in equation (10) is defined in equation $(G.4)$ of Appendix G.

[7] See Appendix E. The model was also estimated using Heckman (1981a)'s approach. See appendices C and F for the details. Overall, both approaches yield qualitatively similar results. For the sake of brevity, we focus on Wooldridge's approach in Tables 2–4. Estimation results using Heckman's specification are available upon request.

[8] The estimates of the nuisance parameters are reported in Table A.1 in Appendix A.

owner in the previous period on current wages and employment. This is a major concern in both the empirical and the theoretical literature. Finally, Specification (3) is similar to Specification (2) except that the interaction between lagged ownership and employment status now distinguishes between outright owners and mortgagors. We do this in order to investigate the claim according to which the search intensity of the former is less than that of the latter (Morescalchi, 2016; Flatau et al., 2003; Brunet et al., 2007; Baert et al., 2014). If the claim is valid then the parameter estimates in the employment and wage equations should differ accordingly.

We begin our discussion of the results by stating general comments about the parameter estimates associated with the demographic variables. We next turn to the interactions between the endogenous variables *per se* and the dynamic links between them.

4.1. Demographics

Most parameter estimates are in agreement with *a priori* expectations. Thus, not surprisingly, individuals who live in couples are more likely to be homeowners (Table 2) and to be employed (Table 3). The same applies to the more educated: They are more likely to be homeowners, to be employed and to enjoy higher earnings. This is consistent with a large literature that concludes likewise (see Haurin et al., 1996). The converse hold for foreigners. Their lower ownership may arise from the fact that they are less likely to be employed (Table 3) and to have lower earnings (Table 4). Recall that homeownership in France is mostly achieved through a combination of mortgage and inheritance and/or family contribution Bayon and Madec (2014). The foreign born perhaps benefit less from such mechanisms, or they may not value homeownership as much as natives (Huber and Schmidt, 2022). Age profiles are also consistent with *a priori* expectations, except perhaps with respect to the homeownership equation. Specification (1) does not control for state dependence or initial conditions. As customarily found in the literature, the probability of owning a house increases with age: Those in the 20–29 and 30–39 age groups have a lower probability than those in the 40–49 age and 50+ age groups. On the other hand, once we control for state dependence and initial conditions, the converse holds (Specifications (2) and (3)). This result, although surprising, must be interpreted with care. Indeed, the age profile in the employment and earnings equations is consistent with the empirical literature in all three specifications: Employment is inversely related to age, *i.e.* it increases until 50 and then decreases (Table 3). Likewise, conditional on working, earnings also increase with age (Table 4). It thus follows that the negative relationship between age and homeownership in Specifications (2) and (3) of Table 2 is found only once we condition on the initial state on the housing market and once we account for the intrinsic inertia on that market (Blanchflower and Oswald, 2013; Kan, 2000). Hence, it may be that older individuals who are tenants at baseline may find it hard to secure a loan (low income and/or poor work history) or may simply prefer not to not become a homeowner.

4.2. Home-ownership

As mentioned above, the parameter estimates of the home-ownership equation are sensitive to the initial conditions and to state dependence. Yet, the variations in the regional mortgage interest rates have the same expected negative impact on home-ownership in all three specifications. Recall from Figure 1(b) that the interest rates varied considerably over our sample period (as well as across regions). Likewise, home-ownership exhibits sizeable state dependence: being employed and homeowner in the previous year increases the likelihood of being a homeowner the next. Note that we do not distinguish between outright owners and mortgagors in this equation. The parameter estimates thus apply to both.

The estimates of the last panel control for the initial employment and ownership statuses.[9] All are statistically different from zero. In particular, they show that an employed individual at t_0, irrespective of his/her tenure status, is marginally less likely to eventually become a homeowner. On the other hand, those who already own a property at t_0 are more likely to remain homeowners in future periods.

4.3. Employment Status

The second panel of Table 3 focuses on the contemporaneous relation between home-ownership and employment. Interestingly, the parameter estimates indicate that outright ownership and employment are not linked. The latter are no more and no less likely to be employed than tenants. On the other hand, mortgagors are indeed found to more likely be employed each period. In other words, they have fewer or shorter unemployment spells than tenants *and* outright owners. This suggests that positive link between ownership and employment are possibly solely driven by mortgagors (Barrios García, 2017; de Graaff and van Leuvensteijn, 2013; Coulson and Fisher, 2009; Munch et al., 2008; Battu et al., 2008). It may thus be conjectured that is not so much the proportion of homeowners that explain lower inflows into unemployment, but the proportion of indebted homeowners (See Baert et al., 2014; Beugnot et al., 2018).

We further investigate the link between home-ownership and employment in the third panel of the table. Specifications (2) and (3) both include lagged employment and ownership status.

[9] See Wooldridge (2005), and in particular parameters λ_{jh} and λ_{je} of equation (E.2) in Appendix E.

They differ only insofar as the the interaction term of the former does not distinguish between ownership status whereas the latter does. In both cases, it is found not surprisingly that being employed at time t is strongly related to the employment status at $t-1$. Lagged ownership status also matters greatly. According to Specification (2), owners (outright and mortgagors) at $t-1$ are more likely to be employed than tenants. Yet, when we interact the ownership status with a dummy indicator for unemployment at $t-1$, we find interesting results. Thus, outright owners who are unemployed in the previous period are less likely than tenants to be employed in the current period ($\chi^2 = 29.30$). Conversely, unemployed mortgagors are no more and no less likely to be employed at t ($\chi^2 = 1.75$).

Specification (2) imposes that the parameter estimate of the interaction term between lagged ownership and unemployment be the same for outright owners and mortgagors. Specification (3) relaxes this assumption. Doing so highlights even more the outright owners and mortgagors behave quite differently on the labour market. Thus, unemployed outright homeowners at $t-1$ are found to be *less* likely to be employed than tenants (-0.39=.42 -0.81, $\chi^2 = 14.32$) whereas mortgagors are more likely to be employed at t than tenants (0.07=.278-.208, $\chi^2 = 5.26$).[10] This reinforces our previous results about the relation between ownership and employment (unemployment). Indeed, once employment and ownership dynamics are accounted for, outright homeowners are found *less* likely to be employed than tenants at t if they were unemployed at $t-1$, whereas the converse holds for mortgagors. This implies that outright homeowners (mortgagors) will experiment longer (shorter) expected unemployment spells than tenants. In a sense, ours results reconcile the empirical literature that finds a positive link between unemployment duration and ownership status (Morescalchi, 2016; Guler and Taskin, 2018), the one that concludes the opposite (Munch et al., 2006; Brunet et al., 2012), and yet that which finds no link between the two (Battu et al., 2008; Brunet et al., 2012; Crusson and Arnault, 2015; Vuuren, 2017). It is perhaps not so much the proportion of homeowners that causes unemployment as the mix between outright and indebted homeowners.

The last panel of the table once again underlines the importance of accounting for the initial conditions. According to the last panel, the employment status at baseline is quite informative. Those who are employed have a lower probability of employment future periods, *ceteris paribus*. Interestingly, the tenure status is unrelated to future emplyment spells.

[10] Formally, the null hypotheses are $H_0 : \beta_{\text{Owner}(100\%)_{t-1}} + \beta_{\text{Unemployed}\times\text{Owner}(100\%)_{t-1}} = 0$ and $H_0 : \beta_{\text{Owner}(<100\%)_{t-1}} + \beta_{\text{Unemployed}\times\text{Owner}(<100\%)_{t-1}} = 0$.

4.4. Earnings Equation

Table 4 focuses on the (log) earnings equation. According to the second panel of Specification (1), outright homeowners and mortgagors enjoy larger conditional expected earnings than tenants by about 4% and 11%, respectively. This is consistent with the findings of Coulson and Fisher (2002), Caliendo et al. (2015) and Munch et al. (2008) according to which one is more likely to secure a loan the larger the expected discounted value of the future stream of earnings. Yet, once we account for state dependence, the results are quite different. First, according to Specification (2) homeowners still enjoy a wage premium. Interestingly, once we interact lagged ownership and unemployment statuses we find that outright owners (-0.02= 0.03-0.05, $\chi^2 = 0.51$) and mortgagors (0.01= 0.06-0.05, $\chi^2 = 0.19$) are no more and no less penalised upon reemployment than tenants. The less restrictive Specification (3) yields a different picture. According to the parameter estimates, outright homeowners suffer a 13% earnings loss upon reemployment (-0.13= 0.04-0.17, $\chi^2 = 14.43$). This is consistent with the results of Guler and Taskin (2018) and Yang (2019). Mortgagors, on the other hand, enjoy a wage increase of approximately 6% upon reemployment (0.06 = 0.06-0.001, $\chi^2 = 5.26$). Once again, our estimates underline the importance of distinguishing between outright homeowners and mortgagors, as well as accounting for the dynamic nature of the adjustment processes. Finally, according to the initial conditions parameters, employed individuals at baseline have a lower conditional expected earnings profile, while the opposite holds for homeowners.

4.5. Marginal Effects

The estimates reported in Tables 2 and 3 can only be assessed with respect to their sign. They do not represent marginal effects such as those of the earnings equation in Table 4. Table 5 thus reports the *per period* marginal effects of the parameters of Specifications (2) and (3) of the home-ownership and employment equations and are computed based on the entire stochastic specification of the model. Note first that the marginal effects of the slope parameters are almost identical across specifications and in both equations and most are statistically significant. In both cases, we find sizeable dynamic dependence in home-ownership (=0.85) but much less so in employment (=0.36). The main difference between Specifications (2) and (3) pertains to the employment equation (and the earnings equations as reported above). According to Specification (2), unemployed outright homeowners at $t-1$ are 3 percentage points less likely to work in period t than tenants. Mortgagors are 2 percentage points less likely. According to Specification (3), outright homeowners are as much as 10 percentage points less likely to work whereas mortgagors are no different from tenants.

4.6. Stochastic Specification

Table A.1 reports the parameter estimates of the stochastic specification. According to the first panel, the variance of the random effects specific to the ownership status is relatively large, indicating important unobserved heterogeneity among homeowners. The variance of the random effect of the (log) earnings equation is relatively small which suggests there is little (conditional) heterogeneity.

The unobserved heterogeneity components specific to the employment and earnings equations, not surprisingly, are positively correlated in all the specifications. Workers are thus a self-selected subset of the population. The same holds for the correlation between the random effects of the ownership and earnings equations in Specifications (2) and (3). Interestingly, we do not observed such correlation between the individual random components of the ownership and the employment equations.

Our specification is flexible enough to model the autocorrelation of the error terms of each endogenous variable. As shown, the error term of the ownership and employment equations are negatively autocorrelated, implying that a negative shock in a given year is likely to affect positively the outcome the following year. Conversely, the error term of the earnings equation is positively and significantly autocorrelated in all three specifications. Finally, our parameter estimates suggests the error terms of all three equations are weakly correlated at best.

5. Conclusion

The motivation of this paper stems from the lack of consensus in the literature concerning the links between homeownership, earnings and unemployment. Conflicting results may arise as a result of failing to properly account for the endogeneity of homeownership and performances on the labour market. In this paper we jointly model homeownership, labour market transitions and earnings. The model incorporates unobserved heterogeneity to account for self-selection into homeownership, employment and earnings. Individual random effects are allowed to be correlated across all equations, just as are the idiosyncratic error terms. In addition, the latter are also allowed to be autocorrelated.

The model is estimated using the French sample of the EU-SILC panel dataset for the period ranging from 2004 to 2013. Importantly, our analysis distinguishes between outright and leveraged homeowners. Further, since we observe many transitions both on the labour and housing markets, we model the past selection mechanisms that led to the initial status appropriately.

Our results are consistent with previous findings insofar as homeowners are found to enjoy longer employment spells and higher earnings. Interestingly, it is also found that outright homeowners experience longer unemployment spells than tenants and earn less than previously upon reemployment. On the other hand, it is also found that mortgagors and tenants behave similarly. Our results also stress the importance of accounting for unobserved heterogeneity in explaining observed transitions on the labour and housing markets, and the relationship between earnings and the latter two. Failure to properly account for this is likely to yield biased parameter estimates. Our results also contribute to the understanding of the interaction between labour and housing markets by putting forth the role of the mortgage market: financial constraints borne by leveraged homeowners might counteract inertia effects induced by homeownership. This issue needs to be investigated more thoroughly in future work. At the aggregate level, thus, the relationship between homeownership and the unemployment rate might thus depend on the share of leveraged homeowners. Hence, Oswalds' conjecture appears to be valid in situations where the proportion of outright homeowners is large. In situations were they are few, increasing the share of homeowners (outright or leveraged) is unlikely to impact the unemployment rate.

References

Andrews, D., and A. Caldera Sanchez (2011) 'The evolution of homeownership rates in selected OECD countries: Demographic and public policy influences.' *OECD Journal: Economic Studies*

Arnold, C. (2016) 'Le parc de logements en france au 1er janvier 2016.' *INSEE Focus*

Baert, Stijn, Freddy Heylen, and Daan Isebaert (2014) 'Does Homeownership Lead to Longer Unemployment Spells? The Role of Mortgage Payments.' *De Economist* 162(3), 263–286

Barrios García, Javier A. (2017) 'Do homeowners cope better with economic crises in terms of employment? An analysis of micro panel data from Spain, 2004–2013.' *Housing Studies* 32(5), 566–583

Battu, Harminder, Ada Ma, and Euan Phimister (2008) 'Housing tenure, job mobility and unemployment in the UK.' *The Economic Journal* 118(257), 311–328

Bayon, Sabine Le, and Pierre Madec (2014) 'L'évolution en Europe du profil des ménages propriétaires pendant la crise.' *Revue d'économie financière* 115(3), 87–108

Beugnot, Julie, Olivier Charlot, and Guy Lacroix (2018) 'Does promoting homeownership always damage labour market performances?' *Journal of Economics*

Blanchflower, David G., and Andrew J. Oswald (2013) 'Does high home-ownership impair the labor market?' *NBER Working Paper.* doi: 10.3386/w19079

Brunet, Carole, Andrew Clark, and Jean-Yves Lesueur (2007) 'Statut résidentiel et durée de chômage en France et au Royaume-Uni.' *Revue française d'Economie* 22(2), 165–190

Brunet, Carole, Nathalie Havet, and Jean-Yves Lesueur (2012) 'La propriété immobilière est-elle un obstacle pour sortir du chômage ?' 200(2), 161–183

Caliendo, Marco, Anne C. Gielen, and Robert Mahlstedt (2015) 'Home-ownership, unemployed's job search behavior and post-unemployment outcomes.' *Economics Letters* 137, 218–221

Cappellari, Lorenzo, and Stephen P. Jenkins (2008) 'Estimating low pay transition probabilities accounting for endogenous selection mechanisms.' *Journal of the Royal Statistical Society: Series C (Applied Statistics)* 57(2), 165–186

Chang, Sheng-Kai (2009) 'Simulation estimation of two-tiered dynamic panel tobit models with an application to the labor supply of married women.' *Journal of Applied Econometrics* 26(5), 854–871

Coulson, Edward, and Lynn Fisher (2002) 'Tenure choice and labour market outcomes.' *Housing Studies* 17(1), 35–49

_ (2009) 'Housing tenure and labor market impacts: The search goes on.' *Journal of Urban Economics* 65(3), 252–264

Crusson, L., and S. Arnault (2015) 'Le parc de logements en France au 1er janvier 2014.' *Insee Focus , Insee*

de Graaff, Thomas, and Michiel van Leuvensteijn (2013) 'A European cross-country comparison of the impact of homeownership and transaction costs on job tenure.' *Regional Studies* 47(9), 1443–1461

Delance, P., and B. Vignolles (2017) 'Ça déménage ? la mobilité résidentielle et ses déterminants'

Dietz, R. D., and D. Haurin (2003) 'The social and private micro-level consequences of homeownership.' *Journal of Urban Economics* 54, 401–450

DiPasquale, D., and E. Glaeser (1999) 'Incentives and social capital: Are homeowners better citizens?' *Journal of Urban Economics* 45(2), 354–384

Duhautois, Richard, Christine Erhel, and Mathilde Guergoat-Larivière (2018) 'State Dependence and Labor Market Transitions in the European Union.' *Annals of Economics and Statistics* (131), 59–82. Publisher: [GENES, ADRES]

Edon, C., and T. Kamionka (2008) 'Modélisation dynamique de la participation au marché du travail des femmes en couple.' *Annales d'économie et de Statistique* 86, 77–108

_ (2014) 'Dynamic labor market behavior of married women with endogenous participation, unemployment, working time and wage.' Mimeo, CREST

Engelhardt, Gary V., Michael D. Eriksen, William G. Gale, and Gregory B. Mills (2010) 'What are the social benefits of homeownership? Experimental evidence for low-income households.' *Journal of Urban Economics* 67(3), 249–258

Flatau, Paul, Matt Forbes, Patric Hendershott, and Gavin Wood (2003) 'Homeownership and unemployment: The roles of leverage and public housing.' *NBER Working Paper*

Geweke, J. (1991) 'Efficient simulation from the multivariate normal and student-t distributions subject to linear constraints'.' In 'Computing Science and Statistics: Proceedings of the twenty-third symposium on the interface' Computing science and statistics American statistical association, Alexandria pp. 571–578

Gilbert, L., T. Kamionka, and G. Lacroix (2011) 'The impact of government-sponsored training programs on the labor market transitions of disadvantaged men.' In 'Advances in Econometrics' (Intech) pp. 953–307. ISBN 978

Glaeser, E., and B. Sacerdote (2000) 'The social consequences of housing.' *Journal of Housing Economics* 9, 1–23

Gouriéroux, C., and A. Monfort (1991) 'Simulated based in econometric models with heterogeneity.' *Annales d'Économie et de Statistique* 20-21, 69–107

_ (1993) 'Simulated based inference : A survey with special reference to panel data models.' *Journal of Econometrics* 59, 5–33

_ (1997) *Simulation-Based Econometric Methods* (Core Lecture Series , Oxford: Oxford University Press)

Green, Richard, and Patric Hendershott (2001) 'Home-ownership and unemployment in the US.' *Urban Studies* 38(9), 1509–1520

Guler, Bulent, and Ahmet Ali Taskin (2018) 'Homeownership and unemployment: The effect of market size.' *Labour Economics* 54(C), 191–209

Hajivassiliou, V., D. McFadden, and P. Ruud (1992) 'Simulation of the multivariate normal orthant probabilites : Methods and programs.' Cowles Foundation, Discussion Paper 1021, Yale University

Haurin, D., S. Hendershott, and S. Wachter (1996) 'Wealth accumulation and housing choices of young households.' *Journal of Housing Research* 8, 137–154

Havet, Nathalie, and Alexis Penot (2010) 'Does home ownership harm labour market performances? A survey.' Working Paper GATE 2010-12

Head, Allen, and Huw Lloyd-Ellis (2012) 'Housing liquidity, mobility, and the labour market.' *Review of Economic Studies* 79(4), 1559–1589

Heckman, J. J. (1981a) 'The incidental parameters problem and the problem of initial conditions in estimating a discrete time-discrete data stochastic process.' In *Structural Analysis of Discrete Data,* ed. C. Manski D. McFadden (MIT Press)

Heckman, James (1981b) 'Heterogeneity and state dependence.' In *Studies in Labor Markets,* ed. Sherwin Rosen (Chicago : University of Chicago Press) chapter 3, pp. 91–139

Heckman, James J., and George J. Borjas (1980) 'Does Unemployment Cause Future Unemployment? Definitions, Questions and Answers from a Continuous Time Model of Heterogeneity and State Dependence.' *Economica* 47(187), 247–283

Hospido, Laura (2015) 'Wage dynamics in the presence of unobserved individual and job heterogeneity.' *Labour Economics* 33, 81–93

Huber, Stefanie J., and Tobias Schmidt (2022) 'Nevertheless, they persist: Cross-country differences in homeownership behavior.' *Journal of Housing Economics*

Hyslop, Dean R. (1999) 'State dependence, serial correlation and heterogeneity in intertemporal labor force participation of married women.' *Econometrica* 67(6), 1255–1294

INSEE (2016) 'Tableaux de l'économie française, Paris'

Johnston, Alison, Gregory W. Fuller, and Aidan Regan (2021) 'It takes two to tango: Mortgage markets, labor markets and rising household debt in Europe.' *Review of International Political Economy* 28(4), 843–873

Kamionka, T. (1998) 'SML estimation in transition models.' *The Econometrics Journal* 1, C129–C153

Kamionka, T., and X. Vu Ngoc (2016) 'Insertion des jeunes sur le marché du travail, diplôme et quartier d'origine: Une modélisation dynamique'.' *Revue économique* 67(3), 463–494

Kan, Kamhon (2000) 'Dynamic Modeling of Housing Tenure Choice.' *Journal of Urban Economics* 48(1), 46–69

Keane, M. (1994) 'A computationally practical simulation estimator for panel data.' *Econometrica* 62, 95–116

Laamanen, Jani-Petri (2017) 'Home-ownership and the labour market: Evidence from rental housing market deregulation.' *Labour Economics* 48, 157–167

Lerbs, Oliver (2011) 'Is there a link between homeownership and unemployment? Evidence from German regional data.' *International Economics and Economic Policy* 8(4), 407–426

Levy, D., and C. Dzikowski (2017) 'En 2014, un quart de la population qui déménage change de département.' INSEE première

Morescalchi, Andrea (2016) 'The Puzzle of Job Search and Housing Tenure: A Reconciliation of Theory and Empirical Evidence.' *Journal of Regional Science* 56(2), 288–312

Munch, J. R., M. Rosholm, and M. Svarer (2006) 'Are home owners really more unemployed?' *Economic Journal* 116, 911–1013

Munch, Jakob-Roland, Michael Rosholm, and Michael Svarer (2008) 'Homeownership, job duration and wages.' *Journal of Urban Economics* 63(1), 130–145

Oswald, A. J. (1996) 'A conjecture on the explanation of high unemployment in the industrialized nations: Part 1.' Research Papers , University of Warwick, Warwick

_ (1997) 'The missing piece of the unemployment puzzle.' mimeo, An inaugural Lecture

_ (1999) 'The housing market and Europe's unemployment: a non-technical paper.' Working paper, University of Warwick, Warwick

Sari, Florent (2015) 'Home-ownership and unemployment: a French test of the Oswald hypothesis.' *Revue d'économie régionale et urbaine* 0(1), 211–250

Séverine, A., L. Crusson, N Donzeau, and C. Rougerie (2015) 'Les conditions de logement fin 2013 : Premiers résultats de l'enquête logement.' Insee Première - Les conditions de logement fin 2013

Vuuren, Aico Van (2017) 'Using a Structural-Form Model to Analyze the Impact of Home Ownership on Unemployment Duration.' *Journal of Applied Econometrics* 32(4), 858–876

Wolf, Nikolaus, and Paul Caruana-Galizia (2015) 'Bombs, homes, and jobs: Revisiting the Oswald hypothesis for Germany.' *Economics Letters* 135(C), 65–68

Wooldridge, J. M. (2005) 'Simple solutions to the initial conditions problem in dynamic, nonlinear panel data models with unobserved heterogeneity.' *Journal of Applied Econometrics* 20, 39–54

Yang, Xi (2019) 'The effects of home ownership on post-unemployment wages.' *Regional Science and Urban Economics* 74, 1–17

Table 1: Sample Characteristics

	2004 Sample	Rotating Group			
		All	Outright	Mortgagor	Tenants
Dependent variables	(1)	(2)	(3)	(4)	(5)
Homeowner	57.34	54.01	20.25	33.76	n.a
Employed	78.85	79.48	81.89	88.18	72.04
Earnings (1,000 × Euros)	18.72	19.02	21.94	22.07	15.32
Education level					
High-School or less	57.17	51.48	58.83	45.21	52.84
Post-Secondary	16.10	17.76	14.56	17.97	18.89
University	26.73	30.76	26.31	36.82	28.27
Household Characteristics					
$20 \leq$ Age ≤ 29	14.97	20.81	2.74	10.46	36.37
$30 \leq$ Age ≤ 39	30.61	28.43	10.12	38.78	28.89
$40 \leq$ Age ≤ 49	32.48	30.23	37.29	36.97	22.18
$50 \leq$ Age ≤ 56	21.94	20.53	49.85	13.79	12.56
Married	61.72	53.18	74.06	67.38	33.56
Gender					
Women	53.60	52.32	53.63	51.03	52.68
Men	46.94	47.68	46.37	48.97	47.32
Urban area					
Paris	16.69	14.57	10.48	13.53	17.13
$200000 \leq$ pop $<$ 2 millions	22.99	23.80	18.26	19.24	29.59
$100000 \leq$ pop < 200000	5.53	5.74	4.55	4.46	7.20
$50000 \leq$ pop < 100000	7.02	7.07	5.27	5.96	8.68
$20000 \leq$ pop < 50000	5.24	5.78	5.71	4.86	6.49
$10000 \leq$ pop < 20000	4.66	5.25	5.45	5.52	4.96
$5000 \leq$ pop < 10000	4.56	4.23	4.50	4.39	4.00
pop < 5000	7.55	6.91	7.16	7.81	6.13
Rural township	25.77	26.65	38.62	34.23	15.82
Citizenship					
French	93.77	94.25	96.75	96.22	91.72
Other	6.23	5.75	3.25	3.78	8.28
Number of individuals	9,678	30,077	6090	10154	13833

Note : SRCV 2004-2013. Percentages.

Table 2: **Home Ownership Equation**

	(1)	(2)	(3)
Constant	0.2999***	-1.2988***	-1.2984***
	(0.0594)	(0.1325)	(0.1328)
Woman	-0.0419**	-0.0125	-0.0126
	(0.0165)	(0.0201)	(0.0205)
Married	0.5860***	0.2367***	0.2367***
	(0.0155)	(0.0206)	(0.0206)
Education			
Middle	0.2274***	0.1473***	0.1474***
	(0.0214)	(0.0276)	(0.0276)
High	0.3452***	0.2769***	0.2770***
	(0.0182)	(0.0228)	(0.0229)
Foreign	-0.6690***	-0.2362***	-0.2361***
	(0.0365)	(0.0453)	(0.0453)
Age			
20–29	-0.0428	-0.0283	-0.0283
	(0.0194)	(0.0283)	(0.0283)
40–49	0.2332***	-0.1490***	-0.1491***
	(0.0145)	(0.0251)	(0.0251)
50+	0.3703***	-0.2058***	-0.2059***
	(0.0187)	(0.0308)	(0.0308)
Mean Interest rate	-0.1152***	-0.1077***	-0.1077***
(regional - stock)	(0.0120)	(0.0256)	(0.0256)
		State dependence	
Employed_{t-1}		0.2453***	0.2447***
		(0.0413)	(0.0417)
Owner_{t-1}		3.3633***	3.3629***
		(0.0487)	(0.0497)
		Initial Conditions	
Employed_0		-0.0376**	-0.0376**
		(0.0150)	(0.0151)
$\text{Owner}(100\%)_0$		0.6728***	0.6726***
		(0.0589)	(0.0596)
$\text{Owner}(< 100\%)_0$		0.4073***	0.4078***
		(0.0491)	(0.0499)

(*) Significant at 10% (**), at 5% (***) at 1% .

Table 3: **Employment Equation**

	(1)	(2)	(3)
Constant	1.0317***	0.4264***	0.4214***
	(0.0239)	(0.0515)	(0.0527)
Woman	-0.5007***	-0.1954***	-0.2007***
	(0.0175)	(0.0174)	(0.0175)
Married	0.0279	0.0335*	0.0309*
	(0.0173)	(0.0183)	(0.0183)
Education			
Middle	0.2356***	0.1532***	0.1504***
	(0.0224)	(0.0232)	(0.0234)
High	0.4475***	0.3237***	0.3263***
	(0.0197)	(0.0204)	(0.0204)
Foreign	-0.5352***	-0.1887***	-0.1914***
	(0.0358)	(0.0349)	(0.0349)
Age			
20–29	-0.1291***	0.0412	0.0400
	(0.0218)	(0.0263)	(0.0263)
40–49	0.1298***	0.0953***	0.0971***
	(0.0178)	(0.0213)	(0.0212)
50+	-0.1041***	-0.1822***	-0.1843***
	(0.0217)	(0.0244)	(0.0244)
Owner$(100\%)_t$	0.0015		
	(0.0353)		
Owner $(< 100\%)_t$	0.0752**		
	(0.0311)		
		State dependence	
Employed$_{t-1}$		1.4421***	1.4456***
		(0.0417)	(0.0427)
Owner$(100\%)_{t-1}$		0.3082***	0.4168***
		(0.0633)	(0.0655)
Owner$(< 100\%)_{t-1}$		0.3320***	0.2785***
		(0.0482)	(0.0487)
(Unemployed$\times$Owner)$_{t-1}$		-0.4083***	
		(0.0335)	
(Unemployed$\times$Owner(100%))$_{t-1}$			-0.8089***
			(0.0497)
(Unemployed$\times$Owner$(< 100\%)$)$_{t-1}$			-0.2078***
			(0.0376)
		Initial Conditions	
Employed$_0$		-0.3547***	-0.3503***
		(0.0136)	(0.0138)
Owner$(100\%)_0$		-0.0306	-0.0345
		(0.0626)	(0.0640)
Owner$(< 100\%)_0$		0.0129	0.0133
		(0.0467)	(0.0469)

(*) Significant at 10% (**), at 5% (***) at 1% .

Table 4: **Earnings Equation**

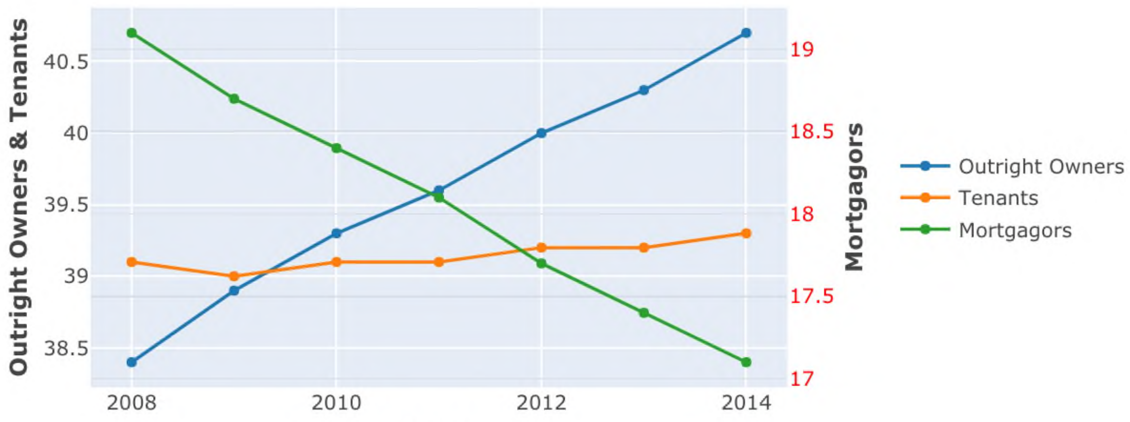
	(1)	(2)	(3)
Constant	9.4428***	8.8162***	8.8124***
	(0.0155)	(0.0212)	(0.0212)
Woman	-0.5700***	-0.3899***	-0.3907***
	(0.0115)	(0.0096)	(0.0096)
Married	0.0077	-0.0152	-0.0152
	(0.0110)	(0.0093)	(0.0094)
Education			
Middle	0.2777***	0.2242***	0.2236***
	(0.0152)	(0.0127)	(0.0127)
High	0.6054***	0.5139***	0.5140***
	(0.0127)	(0.0105)	(0.0105)
Foreign	-0.3096***	-0.0856***	-0.0868***
	(0.0279)	(0.0231)	(0.0230)
Age			
20—29	-0.1483***	-0.0462***	-0.0464***
	(0.0140)	(0.0122)	(0.0122)
40–49	0.1406***	0.0968***	0.0970***
	(0.0107)	(0.0093)	(0.0093)
50+	0.2011***	0.1576***	0.1581***
	(0.0138)	(0.0119)	(0.0119)
Owner$(100\%)_t$	0.0443**		
	(0.0198)		
Owner$(< 100\%)_t$	0.1104***		
	(0.0165)		
		State dependence	
Employed$_{t-1}$		1.0715***	1.0727***
		(0.0140)	(0.0140)
Owner$(100\%)_{t-1}$		0.0355*	0.0420**
		(0.0201)	(0.0201)
Owner$(< 100\%)_{t-1}$		0.0655***	0.0627***
		(0.0140)	(0.0140)
$(\text{Unemployed}\times\text{Owner})_{t-1}$		-0.0552***	
		(0.0202)	
$(\text{Unemployed}\times\text{Owner}(100))_{t-1}$			-0.1779***
			(0.0313)
$(\text{Unemployed}\times\text{Owner}(< 100))_{t-1}$			-0.0047
			(0.0225)
		Initial Conditions	
Employed$_0$		-0.2893***	-0.2868***
		(0.0075)	(0.0075)
Owner$(100\%)_0$		0.0715***	0.0752***
		(0.0233)	(0.0233)
Owner$(< 100\%)_0$		0.1171***	0.1166***
		(0.0166)	(0.0166)

(*) Significant at 10% (**), at 5% (***) at 1% .

Table 5: **Marginal Effects**

SPECIFICATION	HOME OWNERSHIP (2)	HOME OWNERSHIP (3)	EMPLOYMENT (2)	EMPLOYMENT (3)
Woman	-0.001	-0.001	-0.025	-0.025
	(0.001)	(0.001)	(0.002)	(0.002)
Married	0.017	0.017	0.004	0.004
	(0.002)	(0.002)	(0.002)	(0.002)
Education				
Middle	0.010	0.010	0.019	0.018
	(0.002)	(0.002)	(0.003)	(0.003)
High	0.019	0.019	0.040	0.040
	(0.002)	(0.002)	(0.002)	(0.003)
Foreign born	-0.014	-0.015	-0.024	-0.026
	(0.003)	(0.003)	(0.005)	(0.005)
Age (30–39)				
20-29	-0.002	-0.002	0.005	0.005
	(0.002)	(0.002)	(0.003)	(0.003)
40-49	-0.010	-0.010	0.012	0.012
	(0.002)	(0.002)	(0.003)	(0.003)
50+	-0.013	-0.013	-0.024	-0.024
	(0.002)	(0.002)	(0.003)	(0.003)
Interest rate	-0.003	-0.003		
	(0.001)	(0.001)		
		State dependence		
Employed$_{t-1}$	0.016	0.016	0.365	0.364
	(0.003)	(0.002)	(0.014)	(0.015)
Owner$_{t-1}$	0.854	0.853		
	(0.009)	(0.009)		
Owner (100%)$_{t-1}$			0.037	0.049
			(0.007)	(0.007)
Owner (<100%)$_{t-1}$			0.041	0.034
			(0.006)	(0.006)
$(\text{Unemployed} \times \text{Owner})_{t-1}$			-0.062	
			(0.006)	
$(\text{Unemployed} \times \text{Owner}(100))_{t-1}$				-0.142
				(0.012)
$(\text{Unemployed} \times \text{Owner}(< 100))_{t-1}$				-0.029
				(0.006)

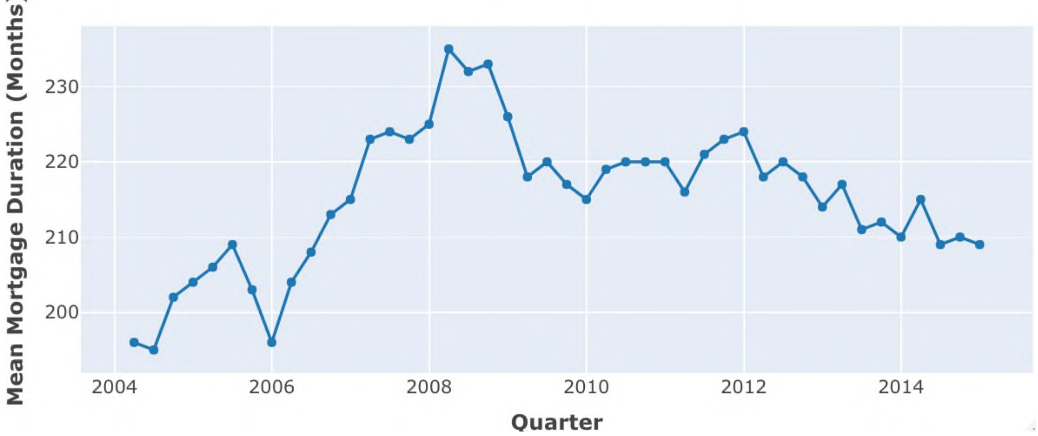
Figure 1: Housing Market



(a) Housing Market Status

(b) Housing price index and interest rate
(*Base=100,* 1^{st} *semester, 2010*)

Figure 2: Mortgage Length
(*Source: Banque de France*)



Appendix

A. Parameter Estimates of the Stochastic Specification

Table A.1: **Stochastic Specification**

	Residuals $r_{jit} = \alpha_{ij} + u_{jit}$ $u_{jit} = \rho_j \, u_{jit-1} + \epsilon_{jit}$		
	(1)	(2)	(3)
	Standard errors of individual effects (α_{ij})		
$\sigma_{\alpha_h} = \frac{\exp(v_h)}{1+\exp(v_h)}$	1.0505***	3.2241**	3.2225*
	(0.1635)	(1.2934)	(1.8868)
$\sigma_{\alpha_e} = \frac{\exp(v_e)}{1+\exp(v_e)}$	-1.3123***	-0.0334	-0.0317
	(0.1059)	(0.0648)	(0.0693)
$\sigma_{\alpha_w} = \exp(v_w)$	-0.6741***	-0.0605***	-0.0583**
	(0.0323)	(0.0230)	(0.0232)
	Correlations between individual effects (α_{ij})		
$\rho_{\alpha_h \alpha_e} = \tanh(c_{he})$	2.8731	0.5976	0.6020
	(6.4576)	(1.1476)	(1.5059)
$\rho_{\alpha_h \alpha_w} = \tanh(c_{hw})$	0.8089***	1.0394	1.0397
	(0.1638)	(2.4093)	(3.5356)
$\rho_{\alpha_e \alpha_w} = \tanh(c_{ew})$	1.1799***	0.4671***	0.4656***
	(0.0640)	(0.0223)	(0.0225)
	Auto-Correlation of error terms (u_{jit})		
$\rho_h = \tanh(d_h)$	2.1807***	-0.0895***	-0.0892***
	(0.0196)	(0.0266)	(0.0266)
$\rho_e = \tanh(d_e)$	0.8905***	-0.1627***	-0.1603***
	(0.0503)	(0.0197)	(0.0199)
$\rho_w = \tanh(d_w)$	0.4962***	0.4185***	0.4183***
	(0.0120)	(0.0109)	(0.0110)
	Correlations between error terms (ϵ_{jit})		
$\rho_{he} = \tanh(f_{he})$	0.0042	0.0615***	0.0622***
	(0.0234)	(0.0223)	(0.0224)
$\rho_{hw} = \tanh(f_{hw})$	0.0193*	0.0177*	0.0173*
	(0.0101)	(0.0095)	(0.0095)
$\rho_{ew} = \tanh(f_{ew})$	-0.0076	0.0714***	0.0717***
	(0.0089)	(0.0074)	(0.0074)
	Standard error of log of wage (u_{wit})		
$\sigma_{u_w} = \exp(f)$	-0.4441***	-0.5809***	-0.5810***
	(0.0082)	(0.0071)	(0.0071)
Number of obs		23,041	

(*) Significant at 10% (**), at 5% (***) at 1% .

B. Identification

Let $U_{ji} = (u_{ji1}, u_{ji2}, \cdots, u_{jiT})'$ denote the vector of the error terms for equation j and for periods 1 to T. Let $E_{ji} = \alpha_{ij}\ \mathbb{1}_T$ for $j \in E$. Then $\tilde{R}_i = (U'_{hi}, U'_{ei}, U'_{wi})' + (E'_{hi}, E'_{ei}, E'_{wi})'$ is a vector of residuals for individual i, for all $i = 1, \ldots, n$. Note that[11]

$$\begin{pmatrix} U_{hi} \\ U_{ei} \\ U_{wi} \end{pmatrix} \sim \text{N}(0, \Sigma_1),$$

where

$$\Sigma_1 = \begin{pmatrix} \kappa_{hh}\ \Psi(\rho_h, \rho_h) & \kappa_{he}\ \Psi(\rho_h, \rho_e) & \kappa_{hw}\ \Psi(\rho_h, \rho_w) \\ \kappa_{he}\ \Psi(\rho_e, \rho_h) & \kappa_{ee}\ \Psi(\rho_e, \rho_e) & \kappa_{ew}\ \Psi(\rho_e, \rho_w) \\ \kappa_{hw}\ \Psi(\rho_w, \rho_h) & \kappa_{ew}\ \Psi(\rho_w, \rho_e) & \kappa_{ww}\ \Psi(\rho_w, \rho_w) \end{pmatrix},$$

and where $\kappa_{jk} = \frac{\rho_{\epsilon_j \epsilon_k}\ \sigma_{\epsilon_j}\sigma_{\epsilon_k}}{(1-\rho_j\ \rho_k)}$ and

$$\Psi(x, y) = \begin{pmatrix} 1 & y & y^2 & \ldots & y^{T-2} & y^{T-1} \\ x & 1 & y & \ldots & y^{T-3} & y^{T-2} \\ \vdots & & \ddots & & & \vdots \\ \vdots & & & \ddots & & \vdots \\ x^{T-2} & & & \ldots & 1 & y \\ x^{T-1} & & & \ldots & x & 1 \end{pmatrix}.$$

The variance of the vector $\tilde{R}_i$ is given by the following equation

$$var(\tilde{R}_i) = \Omega_1 = \Sigma_1 + \begin{pmatrix} \Sigma_{hh} & \Sigma_{he} & \Sigma_{hw} \\ \Sigma_{he} & \Sigma_{ee} & \Sigma_{ew} \\ \Sigma_{hw} & \Sigma_{ew} & \Sigma_{ww} \end{pmatrix},$$

where $\Sigma_{jk} = \rho_{\alpha_j\,\alpha_k}\sigma_{\alpha_j}\sigma_{\alpha_k}\ \mathbb{1}_T\,\mathbb{1}'_T$, $j, k \in E$.

We have necessarily that $0 < \sigma^2_{\alpha_j} < 1$ since $\sigma^2_{\alpha_j} + \sigma^2_{u_j} = 1$ for all $j = h, e$. Note that the parameters σ_{ϵ_j} and ρ_j are identified through the correlations between equation j and the time periods $1 \ldots T$ because the latter are identified in a multivariate probit ($T \geq 2$). Thus σ_{u_j} and σ_{α_j} are identified. Finally, κ_{jk} and $\rho_{\alpha_j\alpha_k}$ are identified through the correlations between equations j and k for $t = 1 \ldots T$. As κ_{jk} is identified, then so is the correlation $\rho_{\epsilon_j\epsilon_k}$.

Consider now $R_i = (r_{hi0}, r_{ei0}, r_{wi0}, r_{hi1}, \ldots, r_{hiT}, \ldots, r_{wi1} \ldots, r_{wiT})'$. Then $R_i \sim N(0, \Omega)$, where

$$\Omega = \begin{bmatrix} \Omega_{00} & \Omega_{0h} & \Omega_{0e} & \Omega_{0w} \\ \Omega'_{0h} & & & \\ \Omega'_{0e} & & \Omega_1 & \\ \Omega'_{0w} & & & \end{bmatrix}, \quad \text{(B.1)}$$

where $\Omega_{00} = Var\begin{pmatrix} r_{hi0} \\ r_{ei0} \\ r_{wi0} \end{pmatrix}$, and $\Omega_{0k} = Cov\left(\begin{pmatrix} r_{hi0} \\ r_{ei0} \\ r_{wi0} \end{pmatrix}, \begin{pmatrix} r_{ki1} \\ \vdots \\ r_{kiT} \end{pmatrix}'\right)$, $k \in E$. The expressions of these variance-covariance matrices are given in Appendix C. With state dependence it is necessary to consider the potential endogeneity of the initial variables save for the wage equation since it is not dynamic and lagged wages are not included in the other equations. These correlations are identified using similar arguments as above.

[11] See Appendix D.

In principle, it would be possible to model the correlations between the error terms of the initial period of equations j (namely r_{ji0}) and the error terms specific to the periods t ($t > 0$) of equation j' ($j' \in E$). Such a specification would involve an unreasonably large number of nuisance parameters was thus not considered. Our specification of the variance-covariance matrix (B.1) is rather similar to the one used by Hyslop (1999) for the US in a single equation model.[12] Moreover, we consider another method to treat the initial conditions problem that was proposed by Wooldridge (2005). If the two methods yield similar results, then it can legitimately be concluded that assumption of homogeneity of the correlations between r_{ji0} and $r_{j'it}$ is not restrictive.

C. Variance-covariance matrices (Heckman' method)

$$\Omega_{00} = \begin{bmatrix} 1 & \rho^0_{he} & \rho^0_{hw}\sigma_{w0} \\ \rho^0_{he} & 1 & \rho^0_{ew}\sigma_{w0} \\ \rho^0_{hw}\sigma_{w0} & \rho^0_{ew}\sigma_{w0} & \sigma^2_{w0} \end{bmatrix},$$

$$\Omega_{0k} = \begin{bmatrix} \rho^{00}_{hk} & \dots & \rho^{00}_{hk} \\ \rho^{00}_{ek} & \dots & \rho^{00}_{ek} \\ \rho^{00}_{wk}\sigma_{w0} & \dots & \rho^{00}_{wk}\sigma_{w0} \end{bmatrix},$$

$k = h, e.$

$$\Omega_{0w} = \begin{bmatrix} \rho^{00}_{hw}\sqrt{\sigma^2_{\alpha_w} + \frac{\sigma^2_{\epsilon_w}}{1-\rho^2_w}} & \dots & \rho^{00}_{hw}\sqrt{\sigma^2_{\alpha_w} + \frac{\sigma^2_{\epsilon_w}}{1-\rho^2_w}} \\ \rho^{00}_{ew}\sqrt{\sigma^2_{\alpha_w} + \frac{\sigma^2_{\epsilon_w}}{1-\rho^2_w}} & \dots & \rho^{00}_{ew}\sqrt{\sigma^2_{\alpha_w} + \frac{\sigma^2_{\epsilon_w}}{1-\rho^2_w}} \\ \rho^{00}_{ww}\sigma_{w0}\sqrt{\sigma^2_{\alpha_w} + \frac{\sigma^2_{\epsilon_w}}{1-\rho^2_w}} & \dots & \rho^{00}_{ww}\sigma_{w0}\sqrt{\sigma^2_{\alpha_w} + \frac{\sigma^2_{\epsilon_w}}{1-\rho^2_w}} \end{bmatrix}$$

D. Autocorrelation (Edon and Kamionka, 2014)

1. Start from the following identity:

$$\begin{aligned} \kappa \equiv cov(u_{jt}, u_{kt}) &= cov(\rho_j\ u_{jt-1} + \epsilon_{jt}, \rho_k\ u_{kt-1} + \epsilon_{kt}) \\ &= \rho_{\epsilon_j\epsilon_k}\ \sigma_{\epsilon_j}\sigma_{\epsilon_k} + \rho_j\rho_k\ cov(u_{jt-1}, u_{kt-1}) \\ \text{so } \kappa &= \frac{\rho_{\epsilon_j\epsilon_k}\ \sigma_{\epsilon_j}\sigma_{\epsilon_k}}{1 - \rho_j\rho_k} \end{aligned}$$

2. Likewise,

$$\begin{aligned} cov(u_{jt}, u_{kt-1}) &= cov(\rho_j\ u_{jt-1} + \epsilon_{jt}, u_{kt-1}) \\ &= \rho_j\ \kappa \\ &\dots \end{aligned}$$

3. Let us assume that $cov(u_{jt}, u_{kt-\ell+1}) = \rho_j^{\ell-1}\ \kappa$, where $\ell \leq t$.

[12]This matrix gives an account of the correlations between the individual effects of the initial observation period with the individual effects of the other periods of time. For the same reason, the matrix $\Omega_1 - \Sigma_1$ consists in the variance-covariance of the individual effects.

4. We now show that $cov(u_{jt}, u_{kt-\ell}) = \rho_j^\ell\, \kappa$. Indeed,

$$\begin{aligned} cov(u_{jt}, u_{kt-\ell}) &= cov(\rho_j\, u_{jt-1} + \epsilon_{jt}, u_{kt-\ell}) \\ &= \rho_j\, cov(u_{jt-1}, u_{kt-\ell}) \\ &= \rho_j\, \rho_j^{\ell-1}\, \kappa \\ &= \rho_j^\ell\, \kappa \end{aligned}$$

It can similarly be shown that $cov(u_{kt}, u_{jt-\ell}) = \rho_k^\ell\, \kappa = cov(u_{jt-\ell}, u_{kt})$.

E. The Initial Conditions Problem

The initial observations at time t_0 do not correspond to the starting time of the data generating process. Hence, the initial state $y_{i0} = (y_{hi0}, y_{ei0}, y_{wi0})'$ is clearly not independent of the individual effects $\alpha_i = (\alpha_{ih}, \alpha_{ie}, \alpha_{iw})'$. Wooldridge (2005) suggests we consider the distribution of the random effects $\alpha_i' = (\alpha_{ih}, \alpha_{ie}, \alpha_{iw})$ conditionally to y_{i0} and, possibly, on a set of exogenous explanatory variables. When this conditional distribution is assumed normally distributed, and given our previous assumptions about the error terms, the likelihood function boils down to the product of integrals defined over multivariate normal density functions.

In practice, it is reasonable to assume that ownership status, employment and earnings are generated by equations (1) to (3). As above, we assume that the error term u_{jit} follow the same autoregressive structure as in equations (5) and (8). We further assume that the conditional distribution of α_{ij} is a normally distribution:

$$\alpha_{ij} \mid y_{i0}, x_i \sim N(\lambda_{j0} + y_{hi0}\, \lambda_{jh} + y_{ei0}\, \lambda_{je}, \sigma^2_{\alpha_j}), \tag{E.2}$$

where λ_{j0}, λ_{jh} and λ_{je} are some real parameters to be estimated and y_{i0}=$(y_{hi0}, y_{ei0},\, y_{wi0})'$. It turns out the constant λ_{j0} cannot be separately identified from the one embedded in β_j. Thus, without lost of generality, we set $\lambda_{j0} = 0$.

Let $\Sigma_1 = var(U_i)$, where $U_i = (U_{hi}', U_{ei}', U_{wi}')'$ and $U_{ji} = (u_{ji1}, \ldots, u_{jiT})'$. Let $E_i = (E_{hi}', E_{ei}', E_{wi}')'$ denote the vector of unobserved heterogeneity terms, where $E_{ji} = \alpha_{ij}\, 1\!\!1_T$ for $j \in E$. As per our previous assumptions, the variance-covariance matrix $\Omega_1 = var(U_i + E_i)$ is the same as that presented in the previous section. The contribution of individual i to the conditional likelihood function is

$$L_i(\theta) = \int_{A_i'} \phi(r; \Omega_1)\, d\, r,$$

where $\phi(.; \Omega_1)$ is the probability density function of a normal distribution with mean zero and variance-covariance matrix Ω_1. The integration is computed over the set

$$A_i' = \left\{ r \in I\!\!R^{3T} : r = (r_{h1}, \ldots, r_{hT}, \ldots, r_{w1}, \ldots, r_{wT}) \text{ and } a_{jit} \leq r_{jt} \leq b_{jit} \right\}.$$

Once again, the domain of integration depends on the realisations of the dependent variables, the explanatory variables and the vector of parameters (see Appendix F).

We can estimate the vector of parameters, θ, by maximising a simulated likelihood function similar to the one defined by the expression (10) using draws $u_i^h = (u_{i1}^h, \ldots, u_{i3T}^h)'$ constructed by a method similar to the one presented in Appendix G and by substituting Ω_1 for Ω.

A lengthy period of observation provides much needed variations in the exogenous variables which help identify the slope parameters of the model. In addition, observing individual households for up to ten years helps identify the nuisance parameters associated with the unobserved heterogeneity components. Finally, the yearly entry of rotating groups within our sample helps identify the parameter estimates of the initial conditions.

F. Domain of Integration

The expressions of the boundaries a_{jit}, b_{jit}, for $j = h, e$ given by

$$\begin{cases} a_{jit} = -\infty, \text{ if } y_{jit} = 0 \text{ and } 0 \leq t \leq T, \\ b_{jit} = +\infty, \text{ if } y_{jit} = 1 \text{ and } 0 \leq t \leq T. \\ a_{jit} = -x'_{jit}\,\beta_j - z_j(y_{it-1}, x_{it-1})'\delta_j, \text{ if } y_{jit} = 1 \text{ and } 1 \leq t \leq T, \\ b_{jit} = -x'_{jit}\,\beta_j - z_j(y_{it-1}, x_{it-1})'\delta_j, \text{ if } y_{jit} = 0 \text{ and } 1 \leq t \leq T, \\ a_{ji0} = -x_{ji0}'\,\beta_j^0, \text{ if } y_{ji0} = 1, \\ b_{ji0} = -x_{ji0}'\,\beta_j^0, \text{ if } y_{ji0} = 0. \end{cases}$$

For earnings, as we have to consider a continuous variable, taking into account they cannot be observed when the individual is not employed ($y_{wit} =$., say), the boundaries are the following ones

$$\begin{cases} a_{wit} = -\infty, \text{ if } y_{jit} = . \text{ and } 0 \leq t \leq T, \\ b_{wit} = +\infty, \text{ if } y_{jit} = . \text{ and } 0 \leq t \leq T, \\ a_{wit} = b_{wit} = y_{wit} - z_w(y_{it-1}, y_{hit})'\delta_w, \text{ if } y_{wit} \neq . \text{ and } 1 \leq t \leq T, \\ a_{wi0} = b_{wi0} = y_{wi0} - x_{wi0}'\beta_w^0, \text{ if } y_{wi0} \neq . \text{ and } t = 0. \end{cases}$$

G. Simulation of a Contribution to the Likelihood Function

Assume that $r \in A_i$ (see section 3.3), where $A_i \subset I\!R^{3(T+1)}$ and $a_{ik} \leq r_k \leq b_{ik}$, $\forall\, k = 1, \ldots, 3(T+1)$. Let L denote the total number of observations per individual (L=3(T+1)).

The contribution of individual i to the likelihood function (9) can be estimated using the expression (see (Geweke, 1991; Hajivassiliou et al., 1992; Keane, 1994; Chang, 2009):

$$\hat{p}_i^S = \frac{1}{S}\sum_{s=1}^{S} \tilde{p}(x_i; u_i^s; \theta), \tag{G.3}$$

where $u_i^s = (u_{i1}^s, u_{i2}^s, \ldots, u_{iL}^s)'$ is a random draw. S is the number of draws used in the estimation and $\tilde{p}$ is an unbiased simulator of probability Prob$[r \in A_i \mid x_i; \theta]$, where r is the vector of error terms for a given individual.

Let $U = \Gamma\, u$ where $\Omega = \Gamma\,\Gamma'$ is the Cholesky decomposition of the matrix Ω. The random variable u is a drawn from the distribution $N(0_L, I_L)$ and Γ is a lower triangular matrix. Assume further that $\Gamma = [\Gamma_{jk}]$, so that Γ_{jk} is the j, k element of the matrix Γ ($j, k = 1, \ldots, L$). Moreover, let $\zeta_{ik} = \frac{a_{ik}}{\Gamma_{kk}}$, $\varphi_{ik} = \frac{b_{ik}}{\Gamma_{kk}}$ and $\Gamma_{jk}^0 = \frac{\Gamma_{jk}}{\Gamma_{jj}}$.

For individual i, the draw s is obtained using a vector u_i^s with length L such that $u_i^s = (u_{i1}^s, u_{i2}^s, \ldots, u_{iL}^s)'$.

In order to obtain the expression of the vector u_i^s each time the likelihood function is computed for a given value of the vector of parameters, we proceed iteratively. Hence, let $\delta_{xy} = 1$ if $x \neq y$ and $\delta_{xy} = 0$ if $x = y$. Note that $a_{ik} = b_{ik}$ if and only if the endogenous variable is not censored (we set in this case $\delta_{\zeta_{ik}\varphi_{ik}} = 0$).

The vector u_i^s is constructed as follows:

- Let $\tilde{u}_{i1}^s \sim U(0,1)$ and set

$$u_{i1}^s = \Phi^{-1}\left[(\Phi(\varphi_{i1}) - \Phi(\zeta_{i1}))\,\tilde{u}_{i1}^s + \Phi(\zeta_{i1})\right]\delta_{\zeta_{i1}\varphi_{i1}} + (1-\delta_{\zeta_{i1}\varphi_{i1}})\,\zeta_{i1}$$

- Let $\tilde{u}^s_{i2} \sim U(0,1)$ and assume that

$$u^s_{i2} = \Phi^{-1}\left[\left(\Phi(\varphi_{i2} - \Gamma^0_{21}\, u^s_{i1}) \right.\right. \\ \left. -\Phi(\zeta_{i2} - \Gamma^0_{21}\, u^s_{i1}) \right) \tilde{u}^s_{i2} + \Phi(\zeta_{i2} - \Gamma^0_{21}\, u^s_{i1}) \Big] \delta_{\zeta_{i2}\varphi_{i2}} \\ + (1-\delta_{\zeta_{i2}\varphi_{i2}})(\zeta_{i2} - \Gamma^0_{21}\, u^s_{i1})$$

- Let $\tilde{u}^s_{iL} \sim U(0,1)$ and assume further that

$$u^s_{iL} = \Phi^{-1}\Big[\big(\Phi(\varphi_{iL} - \Gamma^0_{L\,(L-1)}\, u^s_{i\,(L-1)} - \ldots - \Gamma^0_{L\,1}\, u^s_{i1}) \\ -\Phi(\zeta_{iL} - \Gamma^0_{L\,(L-1)}\, u^s_{i(L-1)} - \ldots - \Gamma^0_{L\,1}\, u^s_{i1}) \big) \tilde{u}^s_{iL} \\ +\Phi(\zeta_{iL} - \Gamma^0_{L\,(L-1)}\, u^s_{i(L-1)} - \ldots - \Gamma^0_{L\,1}\, u^s_{i1}) \Big] \delta_{\zeta_{iL}\varphi_{iL}} \\ + (1-\delta_{\zeta_{iL}\varphi_{iL}})(\zeta_{iL} - \Gamma^0_{L\,(L-1)}\, u^s_{i(L-1)} - \ldots - \Gamma^0_{L\,1}\, u^s_{i1})),$$

  where Φ is the cumulative distribution function of the probability density function $N(0,1)$. We the sequentially obtain all the components of the random draw u^s_i.

The estimation of an individual contribution to the conditional likelihood function can be computed using the empirical mean of the following terms:

$$\tilde{p}(x_i; u^s_i; \theta) = \left[[\Phi(\varphi_{i1} - \Phi(\zeta_{i1})]\delta_{\zeta_{i1}\varphi_{i1}} + (1-\delta_{\zeta_{i1}\varphi_{i1}}) \frac{1}{\Gamma_{11}} \phi(u^s_{i1}) \right] \\ \times \prod_{k=2}^{L} \Bigg[\Big[\Phi(\varphi_{ik} - \Gamma^0_{k\,(k-1)}\, u^s_{i(k-1)} - \ldots - \Gamma^0_{k\,1}\, u^s_{i1}) \\ -\Phi(\zeta_{ik} - \Gamma^0_{k\,(k-1)}\, u^s_{i(k-1)} - \ldots - \Gamma^0_{k\,1}\, u^s_{i1}) \Big] \delta_{\zeta_{ik}\varphi_{ik}} \\ +(1-\delta_{\zeta_{ik}\varphi_{ik}}) \frac{1}{\Gamma_{kk}} \phi(u^s_{ik}) \Bigg], \tag{G.4}$$

where x_i is a vector of explanatory variables for individual i ($i = 1, \ldots, n$) and $h = 1, \ldots, S$. ϕ is the probability density function of the $N(0,1)$ distribution.

CRESTCENTER FOR RESEARCH
IN ECONOMICS AND STATISTICS

CREST
Center for Research in Economics and Statistics
UMR 9194

5 Avenue Henry Le Chatelier
TSA 96642
91764 Palaiseau Cedex
FRANCE

Phone: +33 (0)1 70 26 67 00
Email: info@crest.science
https://crest.science/

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