Crowding-out in savings, portfolio default adoption and home ownership: Evidence from the Chilean retirement system.

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Abstract

This paper studies crowd-out effects across different sources of investment and savings in the Chilean pension system (e.g., voluntary savings within and outside the retirement system, housing status, and default portfolio adoption). Because preferences over choice sets are unobserved and it is expected that individual unobserved characteristics may be correlated across decisions, I jointly estimate a dynamic reduced-form life cycle model of wealth accumulation. Simulation results indicate no short- or long-run crowd-out effects across voluntary savings accounts within and outside the retirement system. There is evidence that in the short run, there is crowding-out between mandatory savings and other forms of investments, such as home ownership or savings in the financial-banking sector. Results also show that in the long run, individuals treat home ownership and participation in voluntary retirement programs as substitute goods. Finally, the long-run effects of participating in voluntary savings programs are important in increasing active participation in portfolio decisions.

Keywords: retirement income policy, default behavior, crowd-out effect.
JEL Classification: J26, J46, C33, C14.

1 Introduction

This paper studies crowd-out effects across different sources of savings, such as voluntary savings accounts within and outside the retirement system, home ownership status, and default portfolio choices in a defined contribution (DC) retirement system.[1,2] In particular, I consider the features of the Chilean retirement model.

The literature has extensively demonstrated the benefits of default rules in DC systems, showing that default enrollment rules and default contribution rules increase participation in retirement savings plans (examples include Madrian and Shea (2001), Thaler and Benartzi (2004), Gelber (2011), Chetty et al. (2014), Thaler (2016)). Nevertheless, it is not clear whether policies that aim to increase retirement savings levels actually increase *total* savings or just savings associated with the retirement system by shifting savings from other sources (Chetty et al., 2014).[3] It is expected that individuals behave differently with respect to choices related to retirement savings and other savings choices (savings in the banking sector, investments in the financial sector, and housing investments, among others). For example, retirement wealth is not liquid, and the rate of returns over retirement savings are different than that over other savings (Attanasio and Brugiavini, 2003).

One of the difficulties in studying crowd-out effects across savings decisions is that individual preferences over choice sets are unobserved (Beshears and Choi, 2012). In particular, workers may have different unobserved preferences for savings, which might be correlated with job selection and savings choices (Gelber, 2011).[4] For example, an individual could select into the formal labor market and commit to contributing to her retirement account while holding voluntary savings because she has a higher unobserved taste for savings. In addition, many papers in the pension literature use reduced-form approaches that do not consider the non-linearity of the individual's maximization problem, and therefore, estimates are biased and inconsistent (Engelhardt and Kumar, 2007). Note that assumptions on individuals' preferences in this

[1] Crowd-out effects are shifts in savings decisions across accounts. For instance, increases in participation in voluntary savings accounts might result in a reduction in savings outside the retirement system

[2] In DC systems, individuals contribute a defined share of their pretax earnings. The pension an individual earns depends on her accumulated savings.

[3] Total savings include mandatory and voluntary savings within the retirement system and savings outside the retirement system.

[4] Through the paper, I refer to this effect as correlated unobserved heterogeneity.

setting can also be risky. It has been shown that there are several variables – beyond the ones considered in neoclassical models – that affect retirement saving choices (Card and Ransom, 2011).

There are several other limitations that have affected the generalization of the results. Many studies rely on policy reforms for identification, which lacks external validity since counterfactuals for alternative reforms are not observed (Blau, 2016). Furthermore, many studies consider small sample sizes or non-representative experiments implemented in particular companies (*e.g.,* Madrian and Shea (2001), Choi et al. (2004), Thaler and Benartzi (2004), Carroll et al. (2009)). Many of these studies consider only the immediate impact of the reforms, and therefore, information about long-run effects is scarce. Finally, papers that use survey data typically have selection bias and measurement error (Engelhardt and Kumar, 2007). Some exceptions to the cases mentioned above are Chetty et al. (2014), who use a 41 million observation administrative dataset from the Danish retirement system, and Engelhardt and Kumar (2007), who use survey data merged with administrative records while controlling for selection using non-standard econometric approaches.

To consider the issues mentioned above, I jointly estimate a multiple reduced-form equation dynamic model of behavior. These equations capture simultaneous decisions such as labor market participation, formality status, contribution status, default adoption in investment portfolios, participation in voluntary savings within and outside the retirement system, and housing asset choices, together with family characteristics that may also affect behavior. In the empirical specification, all equations are correlated through a permanent and a time-varying individual-level unobserved heterogeneity component. The unobserved heterogeneity captures differences in preferences, risk tolerance, tastes, etc. The distribution of these unobserved characteristics is jointly estimated with the coefficients of the model using semi-parametric full information likelihood methods.[5] This approach allows me to address several sources of potential estimation bias: selection, endogeneity, and measurement error.[6] An advantage of the

[5]A complete description of the estimation method is presented in Section 4

[6]Selection bias results from participation behaviors that may be correlated with other modeled behaviors (e.g., optional savings and earnings). Endogeneity bias results from behaviors that are jointly chosen at period t and that depend on previous behaviors (e.g., savings decisions depend on accumulated wealth, which depends on previous decisions). Measurement error is present in self-reported survey measures (e.g., self-reported voluntary savings decisions). Measurement error bias is also reduced by using administrative

estimation method is that it allows me to incorporate the non-linearities that come from the individual's decision-making process without making any assumptions about individual preferences and expectation processes.

Importantly, since I model the individual decision-making process over time, I can analyze crowd-out effects of simulated policies using a representative survey rather than depending on observed policy reforms or experiments for identification. In particular, I use the estimates of the model to simulate contemporaneous (short-run) and life-cycle (long-run) dynamic effects of increasing participation in voluntary retirement accounts, increasing housing assets, and extending compulsory participation on retirement programs to self-employed workers, among others.

With this paper, I extend the current literature in several ways. First, I account for several sources of estimation bias (selection, endogeneity, and measurement error) by using a flexible approach, making few distributional assumptions and no assumptions on individual preferences. Second, rather than studying responses to policy reforms that have been implemented, I estimate a multi-dimension and dynamic model that allows me to simulate effects and responses to policy experiments that have not taken place. Third, I simulate both contemporaneous and life-cycle effects of policies. Fourth, I study crowd-out effects considering different sources of savings with different liquidities (mandatory retirement savings, long-run and short-run voluntary savings, housing) and different employment conditions (formal and informal workers).

I use the first four waves (2002–2009) of the Chilean Survey of Social Protection (EPS from now on) merged with administrative records of the Chilean Bureau of Pensions. The EPS is a validated survey used for the evaluation of retirement policies (Behrman et al., 2011; Joubert, 2015). Using this dataset has several advantages. First, the Chilean model has served as a prototype for the implementation of DC systems in several countries. Analysis of this system is of special interest for other economies that have imported the model.[7] Second, in the Chilean model, there are two levels of default that allow one to study choices and default behavior in different dimensions. On one hand, there are no participation or eligibility conditions once the individual has selected himself into the labor market (the default with the opting out

records on accumulated wealth, rather than relying on self-reported contribution data.

[7]With support of the World Bank, the Chilean experience became an archetype for the implementation of DC systems in Latin America, Europe, and Asia (Orszag and Stiglitz, 2001).

condition is to contribute). On the other hand, once enrolled, workers can choose their own retirement investment portfolio or follow a default portfolio investment scheme provided by the system (opt-out default). Finally, besides including rich individual data and administrative records on retirement wealth, it is a big dataset (more than 7,000 per-year observations for the research sample), and it contains information on different sources of savings.

The remainder of the paper is as follows. The empirical model and estimation strategy are presented in Section 2. Details about the data sources and the research sample are presented in Section 3. Estimation results and policy simulations are presented in Section 5, and finally, Section 6 concludes.

2 Empirical model

The theoretical benchmark is a rational forward-looking individual who maximizes her contemporaneous utility, subject to time and budget constraints, and the discounted value of her expected future utility conditional on current period behaviors. Upon observing a wage offer, individuals make choices about employment status, contribution to the retirement system, investment path default adoption, savings holding, and housing status. Note that the model includes several features of the Chilean pension system.

I do not parameterize and solve the optimization problem but instead use a theoretical life-cycle model to derive estimable approximations of the discrete choice behaviors that define wealth accumulation in the context of a DC retirement system. The empirical model also considers other characteristics, such as marital status and number of children, which depend on an individual's choices and also affect wealth accumulation. For example, wealth accumulation affects the decision to have a child, while having a child might affect savings levels.

The entire system of estimable equations is jointly estimated using a semi-parametric full-information maximum likelihood method that allows me to consider a general pattern of correlation through unobservables across equations.

2.1 Institutional background

The Chilean retirement system was implemented in Chile in 1981 to replace the old pay-as-you-go system. Since the system's beginning, all formal workers have been required to contribute 10% of their pre-tax earnings. Any individual eligible to contribute to the system at least once is enrolled. Enrollees may contribute or not, depending on their employment status.

The contribution is automatically deducted from the worker's monthly paycheck and transferred to her mandatory retirement account. In this paper, I refer to retirement wealth (A_{it}) to denote accumulated assets in the mandatory contribution account. Informal employees, self-employed workers and the non-employed may voluntary contribute or not contribute at all. Contribution choices are denoted by c_{it}. Any individual may hold voluntary savings within the retirement system regardless of her employment and contribution status. Participation choices in retirement voluntary programs are denoted by s^r_{it}.

Enrolled individuals may select one or two voluntary retirement accounts out of five available accounts to invest their retirement wealth and savings. These accounts are offered by the system, and they vary in their level of financial risk. The riskiest fund is Account A, which invests 40–80% in equities, whereas the range for Account B is 25–60%, that of Account C is 15–40%, that of Account D is 5-20%, and that of Account E is less than 5%.

If an individual does not explicitly choose an account, she is defaulted into a pre-determined default investing scheme according to her age and gender. In the default, individuals under the age of 35 are assigned to Account B; women between the ages of 35 and 50 years old are assigned to Account C, and those aged 50+ years old are assigned to Account D. Men between the ages of 35 and 55 are assigned to Account C, whereas those aged 55+ years are assigned to Account D.[8] In the model, portfolio default status is denoted by d_{it}. Note that an individual can choose her default accounts, which means she is not defaulted into that account but she still is observed to be in the default.[9]

[8] A detailed description of the system can be found in Berstein et al. (2010).

[9] This case is treated as a separate category.

2.2 Timing and notation

Each individual i begins period t with an information set Ω_t. The individual observes a wage offer w_{it}^* drawn (which is unobserved for the econometrician) from the wage distribution and jointly decides her employment status (e_{it}), her contribution status (c_{it}) and her portfolio investment status (d_{it}). Additionally, the individual decides whether to hold optional savings within the retirement system (s_{it}^r), outside the retirement system (s_{it}^o), and her housing category (h_{it}): an owner with no loan or an owner but paying, renting, or leasing from a relative.The per period alternatives for these decisions are defined according to the institutional background of the retirement system and considering the survey structure.

Following Joubert (2015), informality is defined according to pension coverage. A worker can be either formal (covered by the pension system) or informal (uncovered by the pension system). Formal workers are dependent employees who sign a contract, while informal workers might be either informal employees (salaried workers who have not signed a contract and therefore are not under social security laws) or self-employed workers (at the time my dataset was constructed, self-employed workers were not required to contribute).

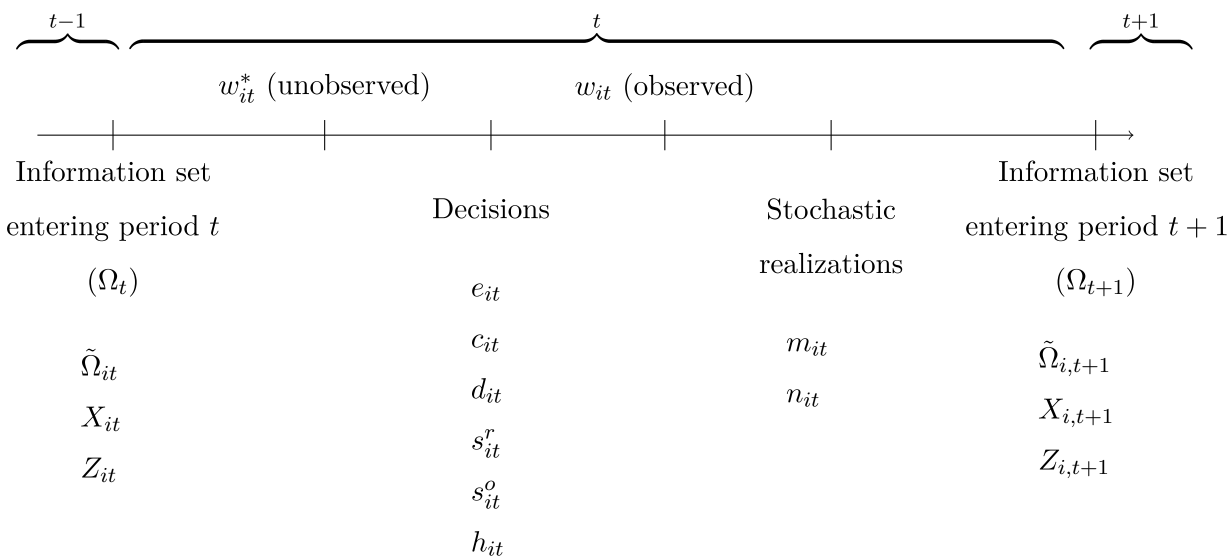
Because these decisions are jointly made, they are all a function of the same observable characteristics summarized in an information set Ω_{it}. The information set contain stock variables up to period $t-1$ and lagged decisions. Lagged decisions include previous contribution status ($c_{i,t-1}$), previous default path adoption ($d_{i,t-1}$), previous housing status ($h_{i,t-1}$), and previous saving choices ($s_{i,t-1}^r$ and $s_{i,t-1}^o$). Stock variables include accumulated assets ($A_{i,t-1}$), accumulated work experience ($E_{i,t-1}$), marriage history ($M_{i,t-1}$) and history of children ($N_{i,t-1}$). Lastly, the set also includes a vector of exogenous individual characteristics (X_{it}, such as age, gender, and education) and a vector of exogenous market-level characteristics (Z_{it}), such as unemployment rates, interests rates, and prices from related markets, among others. I denote $\widetilde{\Omega_{it}}$ as the set conformed by endogenous variables contained in the information set, and Ω_{it} refers to $\{\widetilde{\Omega_{it}}, X_{it}, Z_{it}\}$.

After the decisions are made, the econometrician observes the wage draw w_{it} if the individual is working. The individual observes the realization of her marital status

(m_{it}) and number of children (n_{it}), which are a function of choices in period t, $\tilde{\Omega}_{it}$, X_{it}, and supply-side market-level characteristics (Z_t^M for the marriage market and Z_t^N for the children market).

The individual observes the realization of financial returns and accumulated assets and updates her information set. The individual moves to the next period with information set $\Omega_{i,t+1}$. The timing of the model is presented in Figure 1.

Figure 1: Timing of the model



where $\tilde{\Omega}_t = \{c_{i,t-1}, d_{i,t-1}, s_{i,t-1}^r, s_{i,t-1}^o, h_{i,t-1}, E_{i,t-1}, A_{i,t-1}, M_{i,t-1}, N_{i,t-1}\}$.

2.3 Estimable model

2.3.1 Wages

The wage equation follows a Mincer model (1974) specification and includes individual demographic characteristics (X_{it}), endogenous predetermined variables, such as work experience (E_{it}), and job characteristics (self-employed and informal versus dependent worker). Productivity may also vary among individuals with the same human capital characteristics.[10] Since this productivity is unobserved, I assume that work productivity also depends on family characteristics, such as the number of children and marriage

[10] See Gilleskie et al. (2017) for further details.

duration. I also include demand-side factors (Z^E_{it}) at a regional level. Finally, I also include permanent (μ^1_i) and time-varying unobserved wage determinants (ν^1_{it}).

$$\ln w_{it} \quad = w(e_{it}, \tilde{\Omega}_{it}, X_{it}, Z^E_{it}, \mu^1_i, \nu^1_{it}) \tag{1}$$

2.3.2 Individual choices

Recall that upon observing a wage offer w^*_{it}, individuals make choices with respect to the employment category (e_{it}), retirement contribution status (c_{it}), default adoption status (d_{it}), whether or not to hold voluntary savings both within (s^r_{it}) and outside (s^o_{it}) the retirement system, and her housing status (h_{it}). Nevertheless, these wage offers are unobserved to the econometrician, and she observes only the wage that the individual receives if she decides to be employed, w_{it}. Thus, if there are individual unobserved characteristics that simultaneously affect selection into employment, contribution status (which depends on formality conditions) and wages, there is a risk of potential selection bias. To account for this source of bias, I jointly estimate employment choices with contribution status and wages in period t by allowing for correlation in the error terms that affect each equation.

Moreover, if unobserved characteristics are correlated across savings choices, retirement default portfolio status, and home ownership, then even after correction for selection into employment, potential biases arise. It is expected that saving choices, portfolio choices, and home ownership are endogenous to earnings. Higher earnings may generate higher availability of resources allocated to savings and investments. Similarly, higher earning levels generate higher levels of retirement wealth, which might affect portfolio default adoption.

Consequently, all decisions that impact wealth accumulation are jointly modeled and estimated with wages. Because behaviors are jointly chosen, they are all specified as a function of the variables in the information set Ω_{it}. Behaviors are also specified as a function of equation-specific permanent and time-varying unobserved characteristics. The distribution of these unobserved characteristics is jointly estimated with the parameters of the model. These demand equations representing individual choices are presented from equation 2 to equation 7.

$$\begin{aligned} \ln\left[\frac{P(e_{it}=j)}{P(e_{it}=0)}\right] &= e^j(\tilde{\Omega}_{it}, X_{it}, Z_{it}, \mu_i^2, \nu_{it}^2) \\ & j = \{1,2\} \end{aligned} \tag{2}$$

$$\begin{aligned} \ln\left[\frac{P(c_{it}=j)}{P(c_{it}=0)}\right] &= c^j(\tilde{\Omega}_{it}, X_{it}, Z_{it}, \mu_i^3, \nu_{it}^3) \\ & j = \{1,2\} \end{aligned} \tag{3}$$

$$\begin{aligned} \ln\left[\frac{P(d_{it}=j)}{P(d_{it}=0)}\right] &= d^j(\tilde{\Omega}_{it}, X_{it}, Z_{it}, \mu_i^4, \nu_{it}^4) \\ & j = \{1,2\} \end{aligned} \tag{4}$$

$$\ln\left[\frac{P(s^r_{it}=1)}{P(s^r_{it}=0)}\right] = s^r(\tilde{\Omega}_{it}, X_{it}, Z_{it}, \mu_i^5, \nu_{it}^5) \tag{5}$$

$$\ln\left[\frac{P(s^o_{it}=1)}{P(s^o_{it}=0)}\right] = s^o(\tilde{\Omega}_{it}, X_{it}, Z_{it}, \mu_i^6, \nu_{it}^6) \tag{6}$$

$$\begin{aligned} \ln\left[\frac{P(h_{it}=j)}{P(h_{it}=0)}\right] &= h^j(\tilde{\Omega}_{it}, X_{it}, Z_{it}, \mu_i^7, \nu_{it}^7) \\ & j = \{1,2,3\} \end{aligned} \tag{7}$$

where $\tilde{\Omega}_t = \{c_{i,t-1}, d_{i,t-1}, s^r_{i,t-1}, s^o_{i,t-1}, h_{i,t-1}, E_{i,t-1}, A_{i,t-1}, M_{i,t-1}, N_{i,t-1}\}$. Vector X_{it} includes individual demographic characteristics. Vector Z_t is a vector that includes exogenous market-level characteristics at a regional level from the labor market (such as the unemployment rate, total employment, local minimum wage), from the credit market (share over national deposits and credits, deposits and credits per capita, and banks per capita), the marriage market (gender ratio, marriages per capita) and the family market (college tuition). The equation-specific components μ_i and ν_{it} represent non-linear unobserved heterogeneity that is correlated across equations (from now on, correlated unobserved heterogeneity).

To model this correlation, total unobserved heterogeneity is decomposed into three parts $(\epsilon_{it}, \mu_i, \nu_{it})$. First, there is an idiosyncratic shock that is independent and identically distributed and is assumed to be a type I Extreme Value distributed error (ϵ_{it}), giving the functional form to each choice equation. Second, there is a permanent component that represents permanent unobserved heterogeneity (μ_i). Third, there is a time-varying component that represents time-varying observed heterogeneity (ν_{it}).

The per-period alternatives are constructed based on the survey questions in the data and are the following: $e_{it} = \{0, 1, 2\}$, indicating formal workers, self-employed or informal workers, and non-employed workers, respectively; $c_{it} = \{0, 1, 2\}$, indicating non-contributors, mandatory contributors, and voluntary contributors, respectively;

$d_{it} = \{0, 1, 2\}$, indicating a default into the system's default investment scheme, a choice of the default investment scheme, and a choice to opt out of the default, respectively; $s^r_{it} = \{0, 1\}$, indicating no optional savings or some optional savings within the retirement system; $s^o_{it} = \{0, 1\}$, indicating no or some other savings outside the retirement system; $h_{it} = \{0, 1, 2, 3\}$, indicating a home owner with no loans and a home owner but paying, renting, or leasing from a relative, respectively.

Once choices are made, retirement wealth accumulates according to exogenous market returns R_{it}, which is portfolio-specific, and to new contributions. Thus, retirement wealth at the end of period t is updated as follows:

$$A_{it} = A_{i,t-1} \cdot R_{it}(d_{it}) + 0.1w_{it}$$

2.3.3 Endogenous individual characteristics

While I do not explicitly model changes in marital status and the number of children as choices, I endogenize them into the problem by allowing realizations in period t to depend on current choices (see Figure 1 for the timing). Note that this modeling assumption does not imply that the transitioning of family outcomes are exogenous processes. Because it is expected that unobserved characteristic affect both choices and family outcomes (e.g., an individual may jointly decide her employment status and whether to have children in that period), I allow for correlation between family outcomes and the rest of the equations in the model through an equation-specific permanent and time-varying unobserved component. For example, the evolution of the number of children depends on current employment choices.

The probability of being married ($m_{it} = 1$) relative to not being married ($m_{it} = 0$) is given in equation 8 and depends on period t choices, such as employment status (e_{it}), predetermined state variables ($\tilde{\Omega}_{it}$), and exogenous individual characteristics (X_{it}). Although not modeled explicitly, I assume that there is a marriage market such that supply-side factors (Z^M_{it}) also impact marriage probability. As before, there is a permanent (μ_i) and time-varying (ν_{it}) correlated error term and an idiosyncratic shock (ε_{it}) assumed to be type-I extreme value distributed.

$$\ln\left[\frac{P(m_{it}=1)}{P(m_{it}=0)}\right] = m(e_{it}, \tilde{\Omega}_{it}, X_{it}, Z^M_{it}, \mu^8_i, \nu^8_{it}) \qquad (8)$$

The number of children in the household may increase or decrease over time (due to pregnancies, age of the child, changes in marital status, mortality, etc). These transitions depend on that period's employment decisions (e_{it}), predetermined endogenous choices ($\tilde{\Omega}_{it}$), individual exogenous characteristics (X_{it}), supply-side factors specific to the child market (Z_{it}^N), such as education prices, permanent (μ_i) and time-varying (ν_{it}) correlated unobserved heterogeneity, and a random, type-I extreme value distributed shock (ε_{it}^N). The probability of increasing the number of children ($n_{it} = 1$) and of decreasing the number of children ($n_{it} = -1$) in period t relative to no change ($n_{it} = 0$) is given by:

$$\begin{aligned} \ln\left[\frac{P(n_{it}=j)}{P(n_{it}=0)}\right] &= n^j(e_{it}, \tilde{\Omega}_{it}, X_{it}, Z_{it}^N, \mu_i^9, \nu_{it}^9) \\ & j = \{-1, 1\} \end{aligned} \tag{9}$$

3 Data and research sample

The model is estimated using the first four waves (2002, 2004, 2006, 2009) of the EPS (its name in Spanish is *Encuesta de Protección Social*). The EPS is a longitudinal dataset with rich individual and household information. In this paper, I use the EPS linked with administrative records of wages and accumulated assets of the Chilean Bureau of Pensions (SP for its name in Spanish *Superintendencia de Pensiones*).

The EPS is administered by the Ministry of Labor and Social Security in Chile jointly with the University of Chile and the Institute for Social Research from the University of Michigan. Its design was based on the Health and Retirement Study. Its implementation and partial funding were sponsored by the University of Pennsylvania.

In its first wave, the EPS was designed to be representative of individuals affiliated with the Chilean retirement system. Its subsequent waves were designed to be representative of the entire adult population. The research sample is constructed using individuals present in all four waves, as detailed below.

3.1 Research sample

The sample used in the estimation contains 7,179 individuals observed 4 times. It is restricted in the following way. First, because the objective is to model wealth accumulation through the working life-cycle, all individuals aged from 25 to 59 years old in

2002 are included.[11] Second, due to the dynamic nature of the model, only individuals observed in all four waves (no deaths or attrition) are considered. Third, individuals included have no missing information regarding work experience, optional savings (within and outside the retirement system), marital status, and region of residence.

When considering the individuals included in four consecutive waves, the reference sample (individuals between 25 and 59 years old in 2002) decreases from 13,178 to 7,238 per-year observations. The decision to restrict the research sample is made to exploit the dynamic nature of the model. The model could also be estimated with individuals in three consecutive waves. Nevertheless, most observations are lost after this selection. Thus, I privilege the length of the panel in order to simulate individual policy responses in a 7-year period rather than in a 4-year period.[12] This decision is made after considering that demographic characteristics of all the latter subgroups are similar. Finally, after dropping individuals with missing values for relevant variables, the research sample includes 7,179 per-year observations.

When comparing the reference sample with the research sample the first time it is observed, there are no statistical differences between the average age and the gender shares. The only difference comes in the education category because the reference sample has considerably less missing information for this variable (16% for the reference sample and 1% for the research sample) since most of those individuals attrited or contain missing information for other variables. The share of individuals with less than high school education is higher for the research sample than for the reference sample (53% and 41%, respectively).

Table 1 presents the summary statistics for dependent variables and Table 2 includes the summary statistics for explanatory variables. Note that most individuals in the sample are formal workers. Informality (which include informal employees and self-employed workers) represent around 20% of the sample. Voluntary contributors and individuals who participate in voluntary retirement savings accounts represent 4.5% and 5.6%. The share of individuals who participate in other voluntary savings programs is higher and represents around 14% of the sample. Most individuals are home owners, married, and experience no changes in the number of children in the

[11] The lower limit is defined to simplify the model and to avoid modeling schooling choices.

[12] A total of 8,545 individuals are found in waves 2002, 2004, and 2006, and 8,869 individuals are found in waves 2004, 2006, and 2009.

household.

Table 1: Summary statistics for dependent variables at period t for the research sample

Variable	Mean	S.D.	Min	Max	N
Employment (e_{it})					21,537
Formal worker	0.527	0.499	0	1	
Informal worker	0.195	0.396	0	1	
Not working	0.278	0.448	0	1	
Contribution (c_{it})					21,537
Not contributing	0.486	0.500	0	1	
Mandatory contributor	0.469	0.499	0	1	
Voluntary contributor	0.045	0.207	0	1	
Default (d_{it})					17,979
Defaulted wit no action	0.818	0.386	0	1	
Chose default	0.062	0.241	0	1	
Opted out of default	0.120	0.325	0	1	
Optional savings outcomes					
Within retirement system (s^r_{it})	0.056	0.231	0	1	18,181
Outside retirement system (s^o_{it})	0.137	0.344	0	1	21,516
Housing status (h_{it})					21,537
Owner with no loan	0.608	0.488	0	1	
Owner but paying a loan	0.157	0.364	0	1	
Renting	0.079	0.269	0	1	
Using	0.155	0.362	0	1	
Wage (in logs) (w_{it})	0.659	1.439	-10.217	5.257	14,726
Marital status (married) (m_{it})	0.571	0.495	0	1	21,537
Number of children (n_{it})					21,093
No change	0.788	0.409	0	1	
Decreases	0.184	0.388	0	1	
Increases	0.028	0.165	0	1	

Table 2: Summary statistics for explanatory variables entering period t for the research sample

Variable	Mean	S.D.	Min	Max
Lagged contribution status				
Not contributing	0.479	0.500	0	1
Mandatory contributor	0.471	0.499	0	1
Voluntary contributor	0.05	0.219	0	1
Lagged default status				
Defaulted with no action	0.729	0.444	0	1
Chose default	0.039	0.193	0	1
Opted out of default	0.067	0.249	0	1
Lagged optional savings				
Within retirement system	0.086	0.281	0	1
Outside retirement system	0.154	0.361	0	1
Lagged housing status				
Owner with no loan	0.405	0.491	0	1
Owner but paying a loan	0.111	0.315	0	1
Renting	0.052	0.222	0	1
Using	0.098	0.298	0	1
Retirement wealth (thousands)	7.904	13.917	0	241.593
Work experience (years)	16.431	8.228	0	30
Employment category				
Formal	0.527	0.499	0	1
Informal	0.195	0.396	0	1
Not working	0.278	0.448	0	1
Married	0.571	0.495	0	1
Duration of marriage (years)	12.021	13.01	0	56
Number of children	0.931	1.05	0	7
Age	45.052	9.497	27	66
Education category				
Less than high school	0.539	0.499	0	1
High school	0.351	0.477	0	1
Technical college	0.093	0.291	0	1
College and post-graduate	0.012	0.107	0	1
Unemployment rate	9.08	2.072	4.200	14.500
Total employment (%)	0.381	0.027	0.334	0.457
Minimum wage (relative to vital wage)	39.501	2.803	34.914	49.617
Savings market size (%)	31.962	39.744	0.145	85.205
Credit market size (%)	24.21	29.937	0.246	77.697
Savings per 1000 people	4.888	4.798	0.799	13.036
Credits per 1000 people	4.175	3.429	1.344	10.984
Bank offices per 1000 people	0.111	0.024	0.072	0.185
Bank workers per 1000 people	2.632	1.621	1.102	5.162
Gender ratio (male/female)	0.997	0.367	0.096	3.233
Number of marriages	3.365	0.341	2.500	5.100
College tuition	3.356	0.563	0	4.301
Missing indicators				
Missing: Number of children	0.021	0.142	0	1
Missing: Marriage duration	0.006	0.077	0	1
Missing: Education	0.006	0.075	0	1

4 Estimation

4.1 Error structure

Unobserved individual characteristics also explain the variation in outcomes, as they influence behavior. These unobserved characteristics may be correlated across the $k = \{1, 2, ..., 9\}$ equations of the model.If this heterogeneity is indeed correlated and one does not take it into account, parameters will be estimated with bias. To allow for this correlation to account for this estimation bias, I allow the total error (ε_{it}) in each equation to be decomposed in three parts in the following way:

$$\varepsilon_{it}^k = \mu_i^k + \nu_{it}^k + \epsilon_{it}^k \tag{10}$$

The first (μ_i) and second (ν_{it}) components represent permanent and time-variant unobserved individual characteristics. The third component (ϵ_{it}) is an idiosyncratic independent and identically distributed shock that is assumed to be a type-1 extreme value for discrete dependent variables and normally distributed for continuous dependent variables.

To estimate the parameters of the unobserved heterogeneity distribution, I use a semi-parametric discrete factor random effect (DFRE) estimation method. This methodology is a generalization of Heckman and Singer (1984) by Mroz and Guilkey (1992) and Mroz (1999), which allows the econometrician to not impose any functional or distributional form for the correlated unobserved heterogeneity. Rather, the cumulative distribution of the correlated unobserved factors is approximated by a step function in which the mass points and weights for these distributions are jointly estimated with the other parameters of the model (Guilkey and Lance, 2014).

Since strong assumptions are not imposed over the error distribution, the DFRE estimates reduce the estimation bias and improve the precision of estimates with respect to methods that assume some error distribution (Mroz, 1999; Guilkey and Lance, 2014; Gilleskie et al., 2017).

4.2 Initial condition equations

The analysis begins with the first wave of the EPS, when some of the endogenous variables are non-zero. Since I do not observe the history of decisions before this wave, one cannot use the dynamic specification to explain this variation. Therefore, I specify a static reduced-form equation that depends on exogenous individual characteristics. These initial condition equations are correlated with the dynamic choices and outcomes through the permanent individual unobserved component and are jointly estimated with the rest of equations of the model.

Initial condition equations consider all the endogenous variables entering the first period. These include: employment status (polychotomus: full-time and part-time, self-employed and informal, not employed), years of work experience (continuous variable), contribution status (polychotomus: mandatory, voluntary, not contributing), savings holding inside and outside the retirement system (both dichotomous variables), housing status (polychotomus: owner, owner with loan, renting, lending), marital status (dichotomous) and number of children (continuous). Each initial condition equation is denoted by k where $k = \{10, ..., 17\}$

Thus, the error structure for these 7 initial conditions is as follows:

$$\varepsilon_{it}^{k} = \mu_i^k + \epsilon_{it}^k, \text{ where } k = \{10, ..., 17\} \tag{11}$$

The initial condition equations are identified with exogenous market-level characteristics and individual exogenous characteristics that do not enter subsequent equations (e.g., father's and mother's schooling, household socioeconomic status when growing up, number of siblings when growing up, among others).

4.3 Estimated likelihood function

The likelihood function conditional on the correlated individual unobserved heterogeneity is given by[13]

$$\mathcal{L}_{ct}(\Theta, \mu, \nu_t) = \prod_{i=1}^{N} \left\{ f_w(\mu, \nu_t) \prod_{j=1}^{J} \left[Pr(I(a_t^j = a^j)|\mu, \nu_t) \cdot f_j(\epsilon_t^j|\mu, \nu_t) \right]^{I(a_t^j = a^j)} \right\} \tag{12}$$

where Θ represents the vector of all parameters to be estimated, a_t^j is a choice $j = \{E, C, D, S^r, S^o, H, M, N\}$, $f(\cdot)$ represents the density function of the error term of each equation, $Pr(\cdot)$ is the cumulative distribution function for each choice, and $I(a_t^j = a^j)$ is an indicator of a particular choice.

[13] The subscript i is dropped for simplicity.

The unconditional likelihood function (after integrating both components of the correlated unobserved heterogeneity) for the joint estimation of the system of equation is as follows:

$$\mathcal{L}_t(\Theta) = \sum_{q=1}^{Q} W_{\mu q} \sum_{r=1}^{R} W_{\nu r} \prod_{t=1}^{T} \mathcal{L}_{ct}(\Theta, \mu, \nu_t) \tag{13}$$

where $W_{\mu q}$ is the probability of observing q mass points for the permanent component μ and $W_{\nu r}$ is the probability of observing r mass points for the time-varying component ν_t. These approximate the true distributions of μ and ν_t.

4.4 Identification

Identification comes from several sources. First, identification comes from the non-linear nature of the dynamic system of equations (Guilkey and Lance, 2014; Morales et al., 2016).[14] Second, identification comes from the dynamic nature of the model and the timing assumptions on the decision-making process. These timing assumptions are based on a dynamic life-cycle theoretical model that suggests that pre-determined variables, $\tilde{\Omega}_{it}$, and exogenous market-level variables, $Z_{it} = (Z_{it}^E, Z_{it}^F, Z_{it}^M, Z_{it}^N)$, enter the behavioral equations. Some of these market-level characteristics that explain choices in period t are excluded from the outcome equations in the same period and therefore serve as exclusion restrictions.

For example, wages in period t depend on current characteristics of the labor market (Z_{it}^E) but not on characteristics of other markets, conditional on choices made at period t. Similarly, conditional on choices at period t, only characteristics of the marriage market (Z_{it}^M) and of the family market (Z_{it}^N) affect marital status and children variation, respectively. Moreover, the dynamic specification of the model includes lagged endogenous variables (pre-determined at period t) that are a function of market-level exogenous characteristics (meaning that $Z_{i,t-1}$ explains choices in period $t-1$). This argument follows the standard argument to identify dynamic models (Arellano and Bond, 1991).

Third, the functional form assumption for the distribution of the idiosyncratic component of the error term in each equation (ϵ_{it}) serves to identify the system. Lastly,

[14] Actually, Morales et al. (2016) argue that the second source of identification serves to over-identify the system rather than to identify it, as identification comes from the non-linearity of the system.

this assumption also helps the number of factors allowed for the step approximation for the correlated unobserved heterogeneity.

5 Results

5.1 Specification

The reduced-form life-cycle model consists of 17 jointly estimated equations (equations 1 to 9 plus initial condition equations). The empirical specification is presented Table 3. Note that the table also shows sources of identification based on the theoretical exclusion restrictions and correlation across equations and over time. Explanatory variables can be classified as either pre-determined endogenous variables, exogenous variables, and unobserved heterogeneity. Explanatory variables may enter linearly as higher-order moments and interacted. Predetermined variables capture the dynamic nature of the model. Reduced-form parameters over pre-determined variables, exogenous variables, and unobserved heterogeneity are all jointly estimated.

The total number of estimated parameters is 1,082, where 886 variables correspond to the reduced-form coefficients on the observed characteristics and the rest correspond to the coefficients on the correlated unobserved heterogeneity. The number of mass points and their probability weights are empirically determined. The model that best captures the distribution of unobserved characteristics and that has the best model fit has five mass points for the permanent unobserved heterogeneity and four mass points for the time-varying unobserved heterogeneity.

5.2 Model fit

Before presenting the simulations, I compare the observed data with the simulated outcomes from the data generating process. Evaluating the model fit is an important step since the estimated model is used to simulate counterfactual policies. Thus, we need the model to be a good approximation of the behaviors.

The simulated values are obtained using observed explanatory variables without updating and with 100 replications for the types' probabilities. This comparison is presented in Table 4 and shows that the model fits the data well.

Table 3: Empirical specification of the correlated set of equations

Equation	Explanatory variables		
	Predetermined Variables	Exogenous Variables	Unobserved Heterogeneity
Log wage (w_{it})	e_{it}, E_{it}	X_{it}, Z^E_{it}	μ^1_i, ν^1_{it}, ε^1_{it}
Employment (e_{it})	$c_{i,t-1}$, $d_{i,t-1}$, $h_{i,t-1}$, $s^r_{i,t-1}$, $s^o_{i,t-1}$, A_{it}, E_{it}, M_{it}, N_{it}	X_{it}, $Z^E_{it}, Z^F_{it}, Z^M_{it}, Z^N_{it}$	μ^2_i, ν^2_{it}, ε^2_{it}
Contribution (c_{it})	$c_{i,t-1}$, $d_{i,t-1}$, $h_{i,t-1}$, $s^r_{i,t-1}$, $s^o_{i,t-1}$, A_{it}, E_{it}, M_{it}, N_{it}	X_{it}, $Z^E_{it}, Z^F_{it}, Z^M_{it}, Z^N_{it}$	μ^3_i, ν^3_{it}, ε^3_{it}
Default (d_{it})	$c_{i,t-1}$, $d_{i,t-1}$, $h_{i,t-1}$, $s^r_{i,t-1}$, $s^o_{i,t-1}$, A_{it}, E_{it}, M_{it}, N_{it}	X_{it}, $Z^E_{it}, Z^F_{it}, Z^M_{it}, Z^N_{it}$	μ^4_i, ν^4_{it}, ε^4_{it}
Savings within ret (s^r_{it})	$c_{i,t-1}$, $d_{i,t-1}$, $h_{i,t-1}$, $s^r_{i,t-1}$, $s^o_{i,t-1}$, A_{it}, E_{it}, M_{it}, N_{it}	X_{it}, $Z^E_{it}, Z^F_{it}, Z^M_{it}, Z^N_{it}$	μ^5_i, ν^5_{it}, ε^5_{it}
Savings outside ret (s^o_{it})	$c_{i,t-1}$, $d_{i,t-1}$, $h_{i,t-1}$, $s^r_{i,t-1}$, $s^o_{i,t-1}$, A_{it}, E_{it}, M_{it}, N_{it}	X_{it}, $Z^E_{it}, Z^F_{it}, Z^M_{it}, Z^N_{it}$	μ^6_i, ν^6_{it}, ε^6_{it}
Housing (h_{it})	$c_{i,t-1}$, $d_{i,t-1}$, $h_{i,t-1}$, $s^r_{i,t-1}$, $s^o_{i,t-1}$, A_{it}, E_{it}, M_{it}, N_{it}	X_{it}, $Z^E_{it}, Z^F_{it}, Z^M_{it}, Z^N_{it}$	μ^7_i, ν^7_{it}, ε^7_{it}
Marital status ($m_{i,t+1}$)	e_{it}, E_{it}, M_{it}, N_{it}	X_{it}, Z^M_{it}	μ^8_i, ν^8_{it}, ε^8_{it}
Children in hh ($n_{i,t+1}$)	e_{it}, E_{it}, M_{it}, N_{it}	X_{it}, Z^N_{it}	μ^9_i, ν^9_{it}, ε^9_{it}
Initial conditions ($t=1$)			
Employment (e_{i1})		X_{i1}, $Z^E_{i1}, Z^F_{i1}, Z^M_{i1}, Z^N_{i1}$	μ^{10}_i, ε^{10}_{i1}
Work experience (E_{i1})		X_{i1}, $Z^E_{i1}, Z^F_{i1}, Z^M_{i1}, Z^N_{i1}$	μ^{11}_i, ε^{11}_{i1}
Contribution status (c_{i1})		X_1, $Z^E_{i1}, Z^F_{i1}, Z^M_{i1}, Z^N_{i1}$	μ^{12}_i, ε^{12}_{i1}
Savings within ret (s^r_{i1})		X_{i1}, $Z^E_{i1}, Z^F_{i1}, Z^M_{i1}, Z^N_{i1}$	$\mu^{13}_{i_{i1}}$, ε^{13}_{i1}
Savings outside ret (s^o_{i1})		X_{i1}, $Z^E_{i1}, Z^F_{i1}, Z^M_{i1}, Z^N_{i1}$	$\mu^{14}_{i_{i1}}$, ε^{14}_{i1}
Housing (h_{i1})		X_{i1}, $Z^E_{i1}, Z^F_{i1}, Z^M_{i1}, Z^N_{i1}$	$\mu^{15}_{i_{i1}}$, ε^{15}_{i1}
Marital status (m_{i1})		X_{i1}, Z^M_{i1}	μ^{16}_i, ε^{16}_{i1}
Number of children (n_{i1})		X_{i1}, Z^N_{i1}	μ^{17}_i, ε^{17}_{i1}

Note: (a) All equations are correlated through unobserved heterogeneity separated into μ_i and ν_{it}. Total unobserved heterogeneity includes an idiosyncratic independent and identically distributed error term ε_{it}. (b) The distribution of μ_i and ν_{it} is estimated simultaneously with the reduced-form parameters of the model.

Table 4: Fit of the model

Variable	Observed	Simulated
Employment (e_{it})		
Formal worker	0.527	0.545
Informal worker	0.195	0.184
Not working	0.278	0.272
Contribution (c_{it})		
Not contributing	0.486	0.484
Mandatory contributor	0.469	0.468
Voluntary contributor	0.045	0.048
Default (d_{it})		
Defaulted with no action	0.818	0.831
Chose default	0.062	0.056
Opted out ofdefault	0.100	0.103
Optional savings outcomes		
Within retirement system (s^r_{it})	0.056	0.053
Outside retirement system (s^o_{it})	0.137	0.136
Housing status (h_{it})		
Owner with no loan	0.609	0.617
Owner but paying loan	0.157	0.146
Renting	0.079	0.079
Using	0.155	0.158
Wage (in logs) (w_{it})	0.659	0.689
Marital status (married) (m_{it})	0.576	0.578
Number of children (n_{it})		
No change	0.788	0.782
Decreases	0.187	0.192
Increases	0.026	0.026

5.3 Estimation results

I now refer to the estimation results for those equations that capture individual behaviors that directly impact retirement wealth accumulation (equations 1 to 6). All results tables are presented in the online appendix in Tables A.1 to A.7.[15]

Earnings

There is a statistically significant wage gap of 18.9%. This gap goes in line with other findings in the literature. Using the first three waves of the EPS (2002–2006), Perticará and Bueno (2009) find a wage gap between 12.7% and 18.7%. Using administrative records on unemployment insurance between the years 2004 and 2009, Cruz and Rau (2017) find a wage gap of 24.5%. It is found that informal workers earn 32.3% less than their formal counterparts. No significant effect of children on wages is found. The results show a significant but small effect of marital status.

Employment status (relative to formal workers)

Individuals are significantly less likely to be informal workers or to not work if they were mandatory contributors in the previous period. Individuals with more accumulated wealth and individuals with more accumulated work experience are more likely to be formal workers. As an individual ages, she is more likely to be either informally employed or not employed. There is a significant decrease in the probability of being informally employed or not employed as education increases. I find no gender effect, except for the marriage-female interaction term, meaning that married women are more likely to be informally employed or not employed. I find no significant effect of previous default status or previous savings holdings.

Contribution status (relative to not contributing)

There is significant inertia in contribution status. This means that individuals are significantly more likely to be mandatory (voluntary) contributors if they were mandatory (voluntary) contributors in the previous period. Being a voluntary contributor in the previous period increases the probability of being a mandatory contributor in

[15] Results for the initial condition equations are available from the author.

this period, while the opposite is not true (no significant effect of previous mandatory contribution status on current voluntary status).

Individuals with previous voluntary savings within the retirement system are more likely to contribute, while individuals with previous savings outside the retirement system (e.g., banking) are significantly more likely to be voluntary contributors. This finding suggests that individuals who are not forced to contribute in the retirement system use other available savings tools.

The likelihood of being a mandatory contributor increases as accumulated wealth increases and as accumulated work experience increases (both with significantly diminishing rates). The wealth effect is barely significant for voluntary contributors, and no work experience effect is found.

In both cases, no gender effects are found, except when interacting female with family characteristics (marriage and the number of children). For females, marriage and a greater number of children increase the probability of not contributing. The probability of not contributing decreases as education increases.

Default adoption (relative to defaulting with no action)

Previous contribution status (relative to not contributing in the previous period) increases the probability of choosing or opting out of the portfolio default, relative to following the default. There is also a significant inertia in default status, meaning that an individual is more likely to choose (opt out) the default if chosen (to opt out) previously. Individuals with voluntary savings within the retirement system are significantly more likely to choose the default and to opt out, relative to being assigned the default with no action.

Interestingly, individuals with voluntary savings outside the retirement system are more likely to opt out, but no significant effect is found for choosing the default. This finding suggests that individuals who use savings tools outside the retirement system are more sophisticated in terms of their investment strategies. As retirement wealth increases, individuals are less likely to be assigned to the default.No significant experience effects are found.

Voluntary savings

There is significant inertia in savings status in the previous period. As retirement wealth increases, the likelihood of holding voluntary savings within the retirement system increases, but the same cannot be accepted for savings outside the retirement system. No significant effect of previous contribution status is found, and little effect with respect to previous default adoptions is evidenced. Contrary to our expectations, individuals paying for a home and renting are more likely to hold savings within the retirement system (relative not owning a home).

5.4 Contemporaneous marginal effects

Because the estimated coefficients themselves do not allow one to fully understand the role of choices in current behavior, I calculate the marginal effects of the variables of interest on choices. Marginal effects are computed without any update to current endogenous behaviors in response to previous choices, using the estimated parameters on observed explanatory variables and the estimated distribution of individual unobserved heterogeneity. Because behaviors are not updated in response to previous behaviors, the simulated effects correspond to short-run or contemporaneous effects. Standard errors are calculated using predictions based on 100 draws of the estimated coefficients from the estimated variance-covariance matrix. I focus on the short-run marginal effects of the stock variables of work experience, age and retirement wealth and of the following previous behaviors: lagged optional savings choices and lagged default behavior.

I first focus on the effect of work experience, age and retirement wealth to evaluate how variables that vary through the life cycle affect choices (marginal effects are presented in Table 5). Work experience partially captures experience in the retirement system itself, after controlling for age, while age captures the natural evolution of these choices over time. Retirement wealth accumulation captures the wealth effect of accumulating assets through the life cycle.

A marginal increase in retirement wealth (retirement wealth is defined in thousands of dollars) significantly increases the probability of being a formal worker by 0.12% (column 3 in Table 5). The probability of not contributing to the retirement system and of being assigned to the defaultsignificantly decreases by 0.25% and 0.30%, respectively. An increase in retirement wealth also generates a small but significant (at the 10% level) increase in savings outside the retirement system and in home ownership with a loan (significant at the 5% level). This finding suggests that as retirement wealth needs are covered, individuals switch to other forms of investment. The evolution of investments through the life cycle is not attributable to aging, as the short-run effect of age does not significantly explain portfolio default adoption, savings choices and home ownership (column 2). These results are consistent with other findings in the literature, such as Attanasio and Brugiavini (2003) for Italy and Attanasio and Rohwedder (2003) for the U.K.[16] Unlike Attanasio and Brugiavini (2003), we attribute the switching to retirement wealth rather than to aging. The insignificance of age effects is also consistent with other studies, where for the U.S., using a sample of older individuals, Gustman and Steinmeier (1999) find little and insignificant effects of retirement wealth on other sources of savings. Importantly, note that because individuals are transitioning to other forms of savings, this finding might explain why participation in voluntary savings retirement programs are low.

An additional year of work experience (column 1) mostly explains employment status (e.g., an additional year of work experience significantly increases the probability of being a formal worker by 0.90% and decreases the probability of not working by 1.95%. No effects are found for savings or investment behavior.

Contemporaneous marginal effects of lagged saving choices and default behavior are presented in Table 6. Having optional savings within the retirement system (column 1) significantly decreases the probability of not contributing by 2.30% and increases the probability of mandatory or voluntary contribution by 1.13% and 1.17%, respectively. Having optional savings within the system also significantly decreases the probability of being defaulted into the system's designed portfolio by 4.26%. This latter result could suggest some learning with respect to portfolio choices, as it shows that individuals with higher exposure to the system pursue more sophisticated investment strategies. These results follow the same pattern of results documented by Chetty et al. (2014), who find that active savers are more financially sophisticated than passive savers, among other

[16]In the latter, the authors investigate the crowding-out between public retirement wealth and other sources of savings. This line of study has received great attention. See, for example, Hurd et al. (2012), Arnberg and Barslund (2014), and Blau (2016).

findings.

Similarly, taking an investment action in the previous period (i.e., choosing the default or opting out of the default) significantly decreases the probability of being defaulted by approximately 15% (see columns 3 and 4). Once an individual opts out, the probability of maintaining that decision in the next period significantly increases by 14.67%. This result might suggest that individuals who are sophisticated with respect to their portfolios, tend to follow their own choices rather than following the system's designed investment path. Unlike other papers that evidence inertia in retirement investment decisions once individuals are defaulted into plan characteristics, I find a substantial inertia when individuals decide to opt out of the default (Madrian and Shea, 2001; Choi et al., 2004; Carroll et al., 2009).

As opposed to voluntary savings within the retirement system, there is a substantial inertia in savings outside the retirement system (see column 2). In particular, holding savings outside the system in the previous period significantly increases the probability of holding savings this period by 11.49%. Previous choices with respect to savings outside the system significantly decreases the probability of not contributing to the retirement system by 0.59%. Although this effect follows the same pattern as the effect generated by previous choices with respect to voluntary savings within the retirement system, the effect is significantly smaller (at the 5% level) for savings outside the system. Both previous choices significantly increase the probability of voluntary contribution, but we cannot reject the null that the effects are significantly different from each other.

Some key issues with respect to participation in the retirement system arise from the contemporaneous marginal effects of previous portfolio default adoption. Choosing the default does not generate any significant impact on employment status. Differently, opting out of the default significantly decreases the probability of not working by 2.45%. Recall that these effects are obtained after controlling for other observed variables such as education and work experience and for unobserved heterogeneity, which may capture unobserved preferences toward the labor market. Even though there are no significant impacts on formal market participation, any action taken significantly decreases the probability of not contributing by at least 2% and significantly increases the probability of mandatory contribution by almost 2%. Opting out of the default increases the probability of voluntarily contributing by almost 1%; however, this is not the case for individuals who take action but follow the suggested investment path, where no significant effect is found on voluntary contribution. This finding is an important one, as it suggests that as individuals become more sophisticated in investment strategies over mandatory savings, they are also more likely to go beyond compulsory savings (see Chetty et al. (2014) for a discussion of variables that affect financial sophistication).

Table 5: Contemporaneous marginal effects of stock variables (%)

Behavior	Work experience (1)	Age (2)	Wealth (3)
Employment			
Formal worker	0.90 (0.31)***	-0.78 (0.31)**	0.12 (0.04)***
Informal worker	1.05 (0.36)***	-0.36 (0.45)	-0.21 (0.08)***
Not working	-1.95 (0.56)***	1.13 (0.53)**	0.09 (0.06)
Contribution			
Non-contributor	-12.53 (13.22)	0.62 (0.18)***	-0.25 (0.03)***
Mandatory contributor	14.78 (15.78)	-0.59 (0.17)***	0.23 (0.02)***
Voluntary contributor	-2.25 (5.75)	-0.03 (0.04)	0.02 (0.01)
Default			
Defaulted	0.08 (0.15)	0.16 (0.13)	-0.30 (0.13)**
Chose default	0.03 (0.13)	-0.13 (0.17)	0.10 (0.15)
Opted out of default	-0.11 (0.11)	-0.03 (0.06)	0.20 (0.16)
Optional savings			
Within system	0.00 (0.11)	0.00 (0.01)	0.04 (0.05)
Outside system	0.12 (0.12)	-0.13 (0.09)	0.03 (0.02)*
Housing status			
Owns house (no loan)	0.11 (0.11)	0.11 (0.07)	0.00 (0.07)
Owns house (paying loan)	-0.14 (0.07)**	0.01 (0.08)	0.12 (0.06)**
Rents house	0.00 (0.11)	-0.06 (0.05)	0.00 (0.02)
Uses house	0.03 (0.10)	-0.06 (0.09)	-0.12 (0.08)

Table 6: Contemporaneous marginal effects of previous investment behaviors (%)

Behavior	Lagged optional savings		Lagged default	
	Within system	Outside system	Chose	Opt out
	(1)	(2)	(3)	(4)
Employment				
Formal worker	0.20 (0.62)	0.31 (0.44)	0.77 (1.01)	0.42 (0.99)
Informal worker	0.92 (0.67)	0.37 (0.75)	0.61 (0.99)	2.03 (1.30)
Not working	-1.12 (0.76)	-0.68 (0.80)	-1.38 (1.32)	-2.45 (1.44)*
Contribution				
Non-contributor	-2.30 (0.60)***	-0.59 (0.36)*	-2.11 (0.49)***	-2.40 (0.50)***
Mandatory contributor	1.13 (0.33)***	-0.14 (0.22)	1.49 (0.30)***	1.66 (0.27)***
Voluntary contributor	1.17 (0.49)**	0.73 (0.31)**	0.61 (0.40)	0.74 (0.44)*
Default				
Defaulted	-4.26 (1.65)***	-0.95 (0.70)	-14.64 (4.49)***	-14.77 (5.40)***
Chose default	1.20 (1.75)	0.24 (0.63)	8.32 (7.13)	0.10 (2.62)
Opted out of default	3.06 (2.25)	0.71 (0.71)	6.32 (4.72)	14.67 (7.01)**
Optional savings				
Within system	6.56 (5.82)	1.43 (1.75)	1.05 (1.56)	0.47 (0.93)
Outside system	1.07 (0.72)	11.49 (5.86)*	1.10 (1.01)	0.60 (0.89)
Housing status				
Owns house (no loan)	-1.51 (0.93)	0.65 (0.72)	1.05 (1.44)	-0.72 (1.58)
Owns house (paying loan)	0.96 (0.80)	-0.29 (0.50)	-0.36 (0.92)	-0.50 (1.13)
Rents house	0.21 (0.84)	0.14 (0.66)	-0.14 (1.30)	-0.58 (1.41)
Uses house	0.34 (1.09)	-0.50 (0.69)	-0.55 (1.45)	1.81 (1.54)

5.5 Counterfactual simulations

Crowd-out effects across savings sources in this nonlinear model are best shown with simulations. The simulations quantify the long-run effects of savings decisions by incorporating the dynamic effects of behavior on future outcomes. Because the estimated dynamic decision model allows me to model the sequential process by which individuals make choices, I use the estimated model as the data-generating process and simulate behaviors for 7 years.

Because I aim to quantify long-run effects, the simulated outcomes are used to update the next period's endogenous explanatory variables. Each individual is replicated 100 times, allowing for draws from the unobserved heterogeneity distribution. Each individual is replicated 100 times, allowing draws from the unobserved heterogeneity. Individuals enters the first period with their initial observed characteristics, and the treatment is permanently applied starting in period $t = 2$. Note that results show no effects in the second period because the dynamic nature of the model does not operate within the same period (e.g., current savings behavior does not explain other current choices).

Effect of participating in voluntary savings programs

In the first set of simulations, I evaluate whether there are long-run crowding-out effects across types of savings accounts. Thus, I evaluate what happens to voluntary savings accounts outside the retirement system when all individuals enrolled in the system hold voluntary savings accounts within the retirement system and what happens to the level of accounts within the system when all enrolled individuals maintain savings outside the system.

I find no evidence of the existence of long-run crowding-out effects across these two sources of savings. Table 7 shows the response per period (column 1 for responses in retirement accounts and column 2 for responses in savings outside the system). Note that no effect is statistically significant from zero, meaning that individuals do not treat these two type of accounts as substitute goods. Voluntary savings outside retirement does not significantly affect behaviors within the retirement system, such as the share of individuals with voluntary accounts within the system, contribution status and portfolio default adoption.

Table 8 presents the results of long-run simulations to investigate the effect of holding voluntary savings on portfolio default adoption. All enrolled individuals in the retirement system are treated. First, holding voluntary savings outside the retirement system has no effect on the portfolio choice within the retirement system (column 2). Second, there is evidence of an important long-run effect of holding voluntary retirement savings on portfolio adoption (column 1). For the first two years after the treatment ($t = \{2, 3\}$) the share of individuals who take an action and choose the default significantly increased by approximately 20% and 26%. In the first two years after the treatment, there is no effect on the share of individuals who choose more sophisticated portfolio actions (i.e., opt out). The share of individuals who take an action by choosing the default or by opting out of the default increased by 31% in the first case and by 41% in the second case at $t = 4$. Note that in the last 4 years of the period of analysis, the percentage of enrolled individuals who follow the most sophisticated strategy increases from 41% to 48%. This finding suggests that the long-run effects of participating in voluntary savings programs are very important for increasing active participation in portfolio decisions.

The last simulation used to explore crowd-out effects in the case of voluntary savings is presented in Table 9. The results explore how holding savings accounts impacts home ownership. Again, I find no crowd-out effect between savings outside the retirement system and home ownership (column 2). On the contrary, important implications of holding voluntary savings within the retirement system for home ownership are detected. The share of individuals who are home owners with loans significantly (at the 10%) decreases by approximately between 7% and 10% for the first four years after the treatment. This finding suggests that individuals treat home ownership and participation in voluntary retirement programs as substitute goods. Thus, policy makers should be careful in the design of policies that seek to increase savings within the retirement system, as there might be important welfare implications once the retirement age is reached (i.e., individuals might be better off living with fewer available resources but owning a house rather than renting or paying a mortgage).

Table 7: Crowd-out effects across voluntary savings accounts in the treated group (%)

	Effect of holding voluntary savings within retirement on savings outside retirement (1)	Effect of holding voluntary savings outside retirement on savings within retirement (2)
$t = 3$	0.15 (6.14)	2.16 (15.76)
$t = 4$	0.20 (6.93)	1.56 (18.15)
$t = 5$	0.18 (7.12)	1.35 (17.97)
$t = 6$	0.19 (7.01)	1.15 (18.47)
$t = 7$	0.19 (7.11)	1.17 (18.53)
$t = 8$	0.20 (6.96)	0.67 (19.12)

Note: (a) Simulated percentage change in the outcome of interest when comparing the case where all individuals enrolled hold voluntary savings versus the case where no individual enrolled holds voluntary savings. (b) Individuals begin period $t = 1$ with their observed initial conditions. All individuals enrolled are treated starting in period $t = 2$. The dynamic nature of the model begins to affect outcomes in period $t = 3$. (c) Bootstrapped standard errors are given in parentheses, using 100 draws.

* Significant at the 10 percent level; ** 5 percent level; *** 1 percent level.

Table 8: Effect of holding voluntary savings on default adoption in the treated group (%)

	Voluntary savings within retirement (1)	Voluntary savings outside retirement (2)
Defaulted		
$t = 3$	-10.11 (6.69)	-0.06 (2.08)
$t = 4$	-13.78 (8.90)	-0.10 (2.82)
$t = 5$	-10.96 (9.36)	-0.07 (2.87)
$t = 6$	-9.10 (9.45)	-0.06 (2.79)
$t = 7$	-7.87 (9.30)	-0.05 (2.67)
$t = 8$	-7.50 (9.46)	-0.05 (2.74)
Chose default		
$t = 3$	19.86 (11.11)*	0.21 (4.02)
$t = 4$	25.83 (14.86)*	-0.12 (4.70)
$t = 5$	31.62 (17.71)*	2.53 (5.56)
$t = 6$	25.95 (16.89)	-0.35 (5.86)
$t = 7$	21.23 (17.36)	0.65 (6.22)
$t = 8$	31.14 (16.36)*	0.73 (5.93)
Opted out of default		
$t = 3$	20.47 (12.97)	0.12 (4.44)
$t = 4$	26.77 (17.11)	0.19 (5.76)
$t = 5$	41.15 (20.77)**	0.25 (6.83)
$t = 6$	45.66 (21.34)**	0.31 (7.08)
$t = 7$	48.01 (22.21)**	0.29 (7.23)
$t = 8$	48.64 (21.78)**	0.32 (7.15)

Note: (a) Simulated percentage change in the outcome of interest when comparing the case where all individuals enrolled hold voluntary savings versus the case where no individual enrolled holds voluntary savings. (b) Individuals begin period $t = 1$ with their observed initial conditions. All individuals enrolled are treated beginning in period $t = 2$. The dynamic nature of the model begins affecting outcomes in period $t = 3$. (c) Bootstrapped standard errors are given in parentheses, using 100 draws.

* Significant at the 10 percent level; ** 5 percent level; *** 1 percent level.

Table 9: Effect of holding voluntary savings on default adoption in the treated group (%)

	Voluntary savings within retirement (1)	Voluntary savings outside retirement (2)
Owns home (no loan)		
$t = 3$	-6.55 (3.87)*	0.64 (2.52)
$t = 4$	-9.79 (5.11)*	0.67 (3.44)
$t = 5$	-10.21 (5.57)*	0.51 (3.60)
$t = 6$	-9.58 (5.69)*	0.39 (3.60)
$t = 7$	-8.31 (5.68)	0.31 (3.45)
$t = 8$	-8.45 (6.04)	0.28 (3.63)
Owns home (with loan)		
$t = 3$	3.74 (3.61)	-0.34 (2.80)
$t = 4$	5.17 (5.41)	-0.34 (3.04)
$t = 5$	7.26 (7.40)	-0.36 (4.21)
$t = 6$	9.53 (8.77)	-0.37 (4.61)
$t = 7$	11.90 (10.23)	-0.43 (5.64)
$t = 8$	11.68 (10.35)	-0.38 (5.03)
Rents home		
$t = 3$	-9.49 (8.23)	1.26 (4.23)
$t = 4$	-11.82 (11.57)	1.40 (5.03)
$t = 5$	-11.36 (13.01)	2.07 (5.88)
$t = 6$	-11.47 (13.40)	1.24 (5.69)
$t = 7$	-9.44 (13.22)	1.41 (5.59)
$t = 8$	-8.79 (13.45)	1.74 (6.36)
Uses home		
$t = 3$	-5.65 (6.05)	-0.61 (3.59)
$t = 4$	-9.87 (7.96)	-0.38 (4.56)
$t = 5$	-11.50 (8.48)	-0.30 (4.78)
$t = 6$	-10.94 (8.66)	-0.27 (4.94)
$t = 7$	-10.09 (8.72)	-0.31 (4.91)
$t = 8$	-9.76 (8.46)	-0.38 (4.84)

Note: (a) Simulated percentage change in the outcome of interest when comparing the case where all individuals enrolled hold voluntary savings versus the case where no individual enrolled holds voluntary savings. (b) Individuals begin period $t = 1$ with their observed initial conditions. All individuals enrolled are treated beginning in period $t = 2$. The dynamic nature of the model begins affecting outcomes in period $t = 3$. (c) Bootstrapped standard errors are given in parentheses, using 100 draws.

* Significant at the 10 percent level; ** 5 percent level; *** 1 percent level.

Home ownership effects

To disentangle the crowding-out between voluntary accounts and home ownership status, I now simulate all enrolled individuals to be homeowners (with no loan) and then evaluate how it impacts participation in contributions and in voluntary savings. The results are presented in Table 10.

No significant effect of home ownership is found on savings outside the retirement system. Nevertheless, corroborating the substitution between retirement savings programs and home ownership status, results indicate that once all enrolled individuals are simulated to be homeowners (with no loan), their participation in voluntary retirement programs significantly decreases. Four years after the treatment, there is a decrease in such participation between approximately 16% and 21%. Individuals who are simulated to be homeowners are also less likely to contribute by between approximately 3% and 5% for three years after the treatment and permanently less likely to be mandatory contributors by between approximately 3% and 7%.

Table 10: Effect of home ownership on the treated group (%)

	Voluntary savings within retirement	Voluntary savings outside retirement	Contribution status		
			Non-contributor	Mandatory	Voluntary
	(1)	(2)	(3)	(4)	(5)
$t = 3$	-16.33(9.24)*	0.07 (5.42)	2.75 (1.38)**	-3.14 (0.97)***	-0.02 (3.89)
$t = 4$	-20.86(10.75)*	0.09 (6.73)	4.56 (2.45)*	-5.17 (1.56)***	-0.06 (6.32)
$t = 5$	-21.15(11.04)*	0.08 (6.49)	5.37 (3.26)*	-6.43 (1.91)***	0.12 (7.49)
$t = 6$	-20.10(11.43)*	0.06 (6.58)	5.29 (3.66)	-6.81 (2.11)***	0.05 (8.19)
$t = 7$	-18.19(11.33)	0.05 (6.57)	4.65 (3.76)	-6.64 (2.25)***	-0.02 (8.77)
$t = 8$	-13.79(11.10)	0.04 (6.45)	4.09 (3.98)	-5.79 (2.19)***	0.20 (7.04)

Note: (a) Simulated percentage change in the outcome of interest when comparing the scenario in which all individuals own a home with the scenario in which no individual owns a home. (b) Individuals begin period $t = 1$ with their observed initial conditions. All individuals enrolled are treated beginning in period $t = 2$. The dynamic nature of the model begins affecting outcomes in period $t = 3$. (c) Bootstrapped standard errors are given in parentheses, using 100 draws.
* Significant at the 10 percent level; ** 5 percent level; *** 1 percent level.

Effect of extending mandatory contributions to informal workers

Finally, I evaluate the effect of extending mandatory contributions to informal workers. Recall that following Joubert (2015), informal workers are defined according to their pension coverage. Thus, informal workers might be either informal employees (workers with no contract) or self-employed workers. The first group is harder to follow, as they go beyond the fiscal supervision. Differently, self-employed workers are easier to track, as many of them pay taxes. A policy reform that was passed in Chile in 2008 but will be implemented in 2019 anticipates that self-employed workers will be required to contribute. Because in this research, I cannot separately identify both categories of informal workers, the results are upper bounds of the effects of such a policy.

I run a simulation in which all informal workers contribute. Note that the treated individuals are workers observed to be informal in period t. This specification does not imply that they are not enrolled in the retirement system, as in the past they could have been part of the formal sector. The results are presented in Tables 11 and 12. First, I find no statistically significant long-run effects on voluntary savings participation (columns 1 and 2 in Table 11). Second, based on the workers' observed initial characteristics and the predicted behaviors of the updated model, I find that their likelihood of opting out of the default portfolio significantly increases by between approximately 18% and 28% between the first year after the treatment ($t = 3$) and the last year of the period analyzed ($t = 8$). In periods 5 and 6, treated individuals significantly increase the probability of acting and choosing the default portfolio. These results indicate that forcing contribution does not result in a reduction in other forms of savings accounts. The results also suggest that the treated group will behave as sophisticated investors.

Finally, simulations indicate that home ownership and mandatory contributions work as substitute goods (see Table 12). When forcing individuals to contribute, home ownership significantly decreases (at 10%), between 11% and 12%.

Table 11: Effect of extending mandatory contributions to informal workers (%)

	Voluntary savings within retirement	Voluntary savings outside retirement	Default adoption		
			Defaulted	Chose default	Opted out
	(1)	(2)	(3)	(4)	(5)
$t = 3$	-10.62 (10.40)	-0.04 (5.34)	-6.19 (6.71)	18.54 (13.41)	17.30 (10.29)*
$t = 4$	-11.35 (8.32)	-0.03 (7.27)	-8.45 (8.33)	20.30 (14.29)	21.98 (10.84)**
$t = 5$	-9.07 (8.10)	-0.07 (8.01)	-5.17 (7.81)	26.84 (15.59)*	27.03 (12.46)**
$t = 6$	-9.73 (8.18)	-0.06 (8.66)	-4.01 (7.49)	28.34 (15.47)*	28.11 (11.93)**
$t = 7$	-10.48 (8.96)	-0.06 (9.12)	-3.34 (6.63)	23.83 (15.59)	28.45 (11.81)**
$t = 8$	-5.34 (10.34)	-0.05 (9.23)	-3.14 (6.43)	21.02 (15.38)	28.76 (12.81)**

Note: (a) Simulated percentage change in the outcome of interest when comparing the scenario in which all informal workers are forced to contribute and the scenario in which they are not. (b) Individuals begin period $t = 1$ with their observed initial conditions. All informal workers are treated beginning in period $t = 2$. The dynamic nature of the model begins affecting outcomes in period $t = 3$. (c) Bootstrapped standard errors are given in parentheses, using 100 draws.

* Significant at the 10 percent level; ** 5 percent level; *** 1 percent level.

Table 12: Effect of extending mandatory contributions to informal workers on housing status (%)

	Effect on housing status of extending mandatory contributions to informal workers (1)
Owns home (no loan)	
$t = 3$	-8.45 (6.10)
$t = 4$	-12.17 (6.93)*
$t = 5$	-11.91 (6.67)*
$t = 6$	-11.20 (6.75)*
$t = 7$	-9.62 (6.22)
$t = 8$	-10.64 (7.13)
Owns home (with loan)	
$t = 3$	4.43 (6.33)
$t = 4$	5.98 (8.14)
$t = 5$	8.00 (7.90)
$t = 6$	10.78 (12.08)
$t = 7$	13.53 (17.26)
$t = 8$	14.12 (11.43)
Rents home	
$t = 3$	-4.09 (10.10)
$t = 4$	-2.68 (10.72)
$t = 5$	0.25 (9.95)
$t = 6$	-5.76 (11.19)
$t = 7$	-0.20 (11.72)
$t = 8$	-4.17 (13.06)
Uses home	
$t = 3$	1.56 (7.78)
$t = 4$	-3.17 (9.03)
$t = 5$	-3.15 (8.47)
$t = 6$	-2.40 (8.94)
$t = 7$	-1.43 (9.82)
$t = 8$	-1.16 (8.60)

Note: (a) Simulated percentage change in the outcome of interest when comparing the scenario in which all informal workers are forced to contribute and the scenario in which they are not. (b) Individuals begin period $t = 1$ with their observed initial conditions. All informal workers are treated beginning in period $t = 2$. The dynamic nature of the model begins affecting outcomes in period $t = 3$. (c) Bootstrapped standard errors are given in parentheses, using 100 draws.
* Significant at the 10 percent level; ** 5 percent level; *** 1 percent level.

6 Conclusions

The results indicate no short- or long-run crowd-out effects across voluntary savings accounts within and outside the retirement system. In the short run, it was found that once retirement wealth needs are covered, individuals switch to other forms of investments, such as savings or investment accounts in the banking and financial sector and home ownership. These transitions are not attributable to aging or to gaining experience in the labor market. The transition in savings behaviors might be preventing individuals from participating in voluntary retirement savings programs, as they are rationally making different savings and investment decisions.

Simulations that investigate long-run crowd-out effects also suggest that individuals are treating home ownership and participation in retirement voluntary programs as substitute goods. The same phenomenon is observed with mandatory savings and home ownership.

Once correcting for estimation biases stemming from selection into behaviors and unobserved characteristics that might be correlated across characteristics, the results show that individuals with greater exposure to the retirement system are more sophisticated in selecting investment strategies. In the same way, individuals that are more sophisticated in investment strategies over mandatory savings are also more likely to participate in voluntary retirement savings programs.

The long-run effects of participating in voluntary savings programs are substantial and important for active participation in portfolio decisions. This key finding could be important for the design of default rules. For example, we could consider policies that force individuals to make investment choices rather than assigning them to a default portfolio when no active choice is made. This move could have the increased benefit of increasing participation in voluntary savings programs.

Future research should analyze how crowding-out between participation in voluntary savings programs and home ownership affect resources available after retirement. This direction is important because retirees might be better off by investing in home ownership than in voluntary savings accounts. Nevertheless, this hypothesis is conditional on investigating the amounts of such investments, together with other characteristics of the housing market. This research has considered only the decision to invest.

It would also be of interest to consider intra-household decisions. This research focused on individual behavior with the important feature of the endogenous consideration of family characteristics. However, it did not account for decisions that might occur in the household.

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Online appendix

A Estimation results

Table A.1: Wage equation

Variable	Wage (log)	
	Coeff.	St.Er.
Informal worker	-0.323	0.043***
Work experience	0.019	0.007***
Work experience squared	0.000	0.000**
Female	-0.189	0.024***
High school	0.324	0.024***
Technical college	1.119	0.034***
College	1.301	0.079***
Number of children	0.003	0.010
Marriage duration if married	0.004	0.001***
Unemployment rate	-0.004	0.005
Total employment (%)	2.716	0.412***
Minimum wage (relative to vital wage)	0.037	0.006***
Time trend	-0.129	0.008***
Missing: Education	0.696	0.125***
Missing: Number of children	0.020	0.066
Missing: Marriage duration	0.250	0.124**
Constant	-1.576	0.239***
Permanent Unob. Het	0.154	0.031***
Permanent Unob. Het	-3.922	0.053***
Permanent Unob. Het	0.054	0.031*
Permanent Unob. Het	-0.004	0.046
Time-varying Unob. Het	0.216	0.069***
Time-varying Unob. Het	0.132	0.045***
Time-varying Unob. Het	-0.015	0.060

*, **, *** Significant at the 10%, 5%, and 1% levels

Table A.2: Multinomial logit on employment status (relative to formal workers)

Variable	Informal		Not working	
	Coeff.	St.Er.	Coeff.	St.Er.
Lagged contribution status: Mandatory contributor	-12.277	0.442***	-11.173	0.430***
Lagged contribution status: Voluntary contributor	-0.816	0.325**	-1.166	0.316***
Lagged default status: Chose default	-0.212	0.427	-0.352	0.425
Lagged default status: Opted out of default	0.040	0.339	-0.300	0.333
Lagged housing status: Owner but paying	-0.510	0.293*	-0.673	0.284**
Lagged housing status: Renting	-0.457	0.383	-0.815	0.375**
Lagged housing status: Using	-0.830	0.283***	-0.714	0.273***
Lagged voluntary savings: Within system	0.015	0.303	-0.138	0.296
Lagged voluntary savings: Outside system	-0.072	0.228	-0.148	0.220
Retirement wealth	-0.070	0.011***	-0.043	0.011***
Retirement wealth squared	0.000	0.000***	0.000	0.000***
Work experience	-0.219	0.021***	-0.437	0.020***
Marriage duration if married	-0.014	0.008*	-0.014	0.008*
Number of children	-0.106	0.100	-0.182	0.100*
Interaction: Female-married	1.202	0.295***	1.679	0.282***
Interaction: Female-children	0.085	0.139	0.365	0.135***
Female	-0.315	0.248	-0.038	0.240
Age	0.376	0.041***	0.536	0.040***
Age squared	-0.032	0.008***	-0.047	0.008***
High school	-1.292	0.177***	-1.607	0.172***
Technical college	-2.505	0.315***	-3.011	0.315***
College	-3.399	0.758***	-4.176	0.743***
Unemployment rate	0.023	0.063	0.050	0.061
Total employment (%)	15.400	10.447	12.144	10.267
Minimum wage (relative to vital wage)	-0.104	0.067	-0.089	0.064
Savings market size (%)	-0.080	0.060	-0.018	0.057
Credit market size (%)	0.051	0.052	0.002	0.050
Savings per 1000 people	-1.299	0.473***	-1.284	0.460***
Credits per 1000 people	-0.330	0.255	-0.072	0.245
Bank offices per 1000 people	-51.837	14.246***	-47.143	14.039***
Bank workers per 1000 people	5.852	1.464***	4.645	1.431***
Number of marriages	0.197	0.260	0.282	0.251
College tuition	-0.075	0.399	-0.231	0.386
Gender ratio (male/female)	-0.131	0.263	-0.321	0.255
Time trend	0.275	0.130**	0.397	0.126***
Missing: Education	-0.758	1.157	-0.374	1.093
Missing: Number of children	-0.859	0.524	-1.008	0.519*
Missing: Marriage duration	0.527	0.856	1.020	0.836
Constant	-16.624	5.525***	-7.380	4.935
Permanent Unob. Het	-6.704	0.433***	-6.283	0.428***
Permanent Unob. Het	-4.406	0.498***	-5.888	0.528***
Permanent Unob. Het	-6.377	0.282***	-5.859	0.277***
Permanent Unob. Het	-3.450	0.349***	-5.494	0.341***
Time-varying Unob. Het	34.574	2.063***	26.625	0.632***
Time-varying Unob. Het	14.348	1.768***	7.279	0.224***
Time-varying Unob. Het	22.055	1.904***	15.034	0.410***

*, **, *** Significant at the 10%, 5%, and 1% levels.

Table A.3: Multinomial logit on contribution status (relative to not contributing)

Variable	Mandatory		Voluntary	
	Coeff.	St.Er.	Coeff.	St.Er.
Lagged contribution status: Mandatory contributor	10.411	0.689***	-0.032	0.128
Lagged contribution status: Voluntary contributor	2.211	0.271***	14.191	0.702***
Lagged default status: Chose default	0.540	0.375	0.278	0.270
Lagged default status: Opted out of default	0.600	0.301**	0.332	0.207
Lagged housing status: Owner but paying	0.501	0.201**	0.219	0.185
Lagged housing status: Renting	0.377	0.252	0.030	0.248
Lagged housing status: Using	0.490	0.199**	0.032	0.165
Lagged voluntary savings: Within system	0.410	0.225*	0.503	0.172***
Lagged voluntary savings: Outside system	-0.046	0.158	0.327	0.130**
Retirement wealth	0.092	0.009***	0.011	0.006*
Retirement wealth squared	-0.001	0.000***	0.000	0.000
Work experience	0.305	0.029***	0.026	0.033
Work experience squared	-0.005	0.001***	0.000	0.001
Marriage duration if married	0.007	0.005	0.009	0.005*
Number of children	0.230	0.082***	-0.009	0.062
Interaction: Female-married	-0.738	0.202***	-0.607	0.191***
Interaction: Female-children	-0.225	0.109**	-0.126	0.104
Female	0.149	0.184	0.164	0.163
Age	-0.277	0.031***	0.037	0.029
Age squared	0.017	0.006***	-0.012	0.006**
High school	0.747	0.129***	0.350	0.110***
Technical college	1.012	0.240***	0.424	0.200**
College	2.354	0.626***	1.777	0.477***
Unemployment rate	-0.046	0.041	-0.037	0.036
Total employment (%)	-11.920	5.102**	4.444	5.620
Minimum wage (relative to vital wage)	0.124	0.049**	0.146	0.047***
Savings market size (%)	-0.003	0.041	-0.031	0.038
Credit market size (%)	0.042	0.036	0.023	0.032
Savings per 1000 people	1.359	0.352***	-0.020	0.296
Credits per 1000 people	-0.195	0.182	-0.102	0.159
Bank offices per 1000 people	48.668	9.584***	-15.561	9.645
Bank workers per 1000 people	-4.674	1.092***	0.666	0.939
Number of marriages	-0.274	0.194	-0.081	0.166
College tuition	0.151	0.272	-0.147	0.220
Gender ratio (male/female)	0.151	0.194	-0.160	0.181
Time trend	-0.198	0.080**	-0.249	0.083***
Missing: Education	-1.473	0.632**	1.218	0.679*
Missing: Number of children	1.247	0.495**	-0.080	0.367
Missing: Marriage duration	-1.012	0.611*	0.984	0.636
Constant	2.296	2.548	-31.055	2.853***
Permanent Unob. Het	3.301	0.300***	-0.407	0.182**
Permanent Unob. Het	2.646	0.346***	0.528	0.266**
Permanent Unob. Het	3.096	0.241***	-0.313	0.152**
Permanent Unob. Het	2.802	0.250***	-0.196	0.297
Time-varying Unob. Het	-35.305	1.035***	24.598	1.020***
Time-varying Unob. Het	-5.399	0.206***	9.743	1.488***
Time-varying Unob. Het	-12.388	0.657***	9.885	1.495***

*, **, *** Significant at the 10%, 5%, and 1% levels.

Table A.4: Multinomial logit on default adoption (relative to being assigned the default with no action)

Variable	Chose default		Opted out of default	
	Coeff.	St.Er.	Coeff.	St.Er.
Lagged contribution status: Mandatory contributor	0.766	0.111***	0.590	0.080***
Lagged contribution status: Voluntary contributor	0.446	0.180**	0.435	0.127***
Lagged default status: Chose default	1.831	0.110***	1.203	0.104***
Lagged default status: Opted out of default	0.614	0.125***	1.722	0.077***
Lagged housing status: Owner but paying	-0.016	0.119	-0.040	0.087
Lagged housing status: Renting	0.000	0.157	-0.109	0.120
Lagged housing status: Using	-0.094	0.142	-0.189	0.107*
Lagged voluntary savings: Within system	0.464	0.096***	0.530	0.076***
Lagged voluntary savings: Outside system	0.106	0.084	0.132	0.066**
Retirement wealth	0.043	0.004***	0.045	0.004***
Retirement wealth squared	0.000	0.000***	0.000	0.000***
Work experience	0.007	0.022	0.019	0.017
Work experience squared	0.000	0.001	-0.001	0.001**
Marriage duration if married	0.002	0.003	-0.005	0.003
Number of children	-0.054	0.043	-0.004	0.034
Interaction: Female-married	0.102	0.134	0.173	0.102*
Interaction: Female-children	-0.046	0.071	-0.065	0.053
Female	-0.279	0.117**	-0.130	0.089
Age	-0.043	0.007***	-0.011	0.006**
High school	0.805	0.085***	0.665	0.064***
Technical college	1.312	0.114***	1.120	0.088***
College	1.231	0.253***	1.316	0.193***
Unemployment rate	0.037	0.021*	0.047	0.017***
Total employment (%)	-0.481	1.187	-8.785	1.030***
Minimum wage (relative to vital wage)	0.036	0.033	-0.004	0.026
Savings market size (%)	-0.065	0.024***	-0.006	0.018
Credit market size (%)	0.069	0.022***	0.037	0.016**
Savings per 1000 people	0.645	0.194***	0.600	0.150***
Credits per 1000 people	-0.321	0.106***	-0.196	0.079**
Bank offices per 1000 people	9.508	1.111***	25.435	1.149***
Bank workers per 1000 people	-1.006	0.367***	-2.111	0.284***
Number of marriages	-0.133	0.139	0.152	0.102
College tuition	-0.126	0.144	-0.179	0.115
Gender ratio (male/female)	-0.103	0.149	0.053	0.088
Time trend	-0.265	0.049***	-0.073	0.038*
Missing: Education	0.428	0.466	0.723	0.310**
Missing: Number of children	-0.157	0.208	0.202	0.155
Missing: Marriage duration	0.434	0.369	-0.447	0.367
Constant	-2.571	1.022**	0.411	0.837
Permanent Unob. Het	0.747	0.120***	0.677	0.094***
Permanent Unob. Het	0.301	0.192	0.419	0.146***
Permanent Unob. Het	0.522	0.120***	0.381	0.093***
Permanent Unob. Het	-0.277	0.238	-0.220	0.161
Time-varying Unob. Het	-0.912	0.145***	-0.754	0.106***
Time-varying Unob. Het	-0.490	0.159***	-0.503	0.125***
Time-varying Unob. Het	-1.319	0.183***	-1.311	0.115***

*, **, *** Significant at the 10%, 5%, and 1% levels.

Table A.5: Multinomial logit on voluntary savings within and outside the retirement system (relative to holding no savings)

Variable	Within system (relative to no savings)		Outside system (relative to no savings)	
	Coeff.	St.Er.	Coeff.	St.Er.
Lagged contribution status: Mandatory contributor	0.137	0.102	0.008	0.059
Lagged contribution status: Voluntary contributor	0.158	0.168	0.091	0.097
Lagged default status: Chose default	0.286	0.129**	0.130	0.097
Lagged default status: Opted out of default	0.136	0.110	0.072	0.080
Lagged housing status: Owner but paying	0.439	0.099***	-0.007	0.070
Lagged housing status: Renting	0.250	0.143*	-0.155	0.100
Lagged housing status: Using	0.017	0.130	-0.144	0.079*
Lagged voluntary savings: Within system	1.306	0.084***	0.127	0.068*
Lagged voluntary savings: Outside system	0.389	0.079***	1.104	0.047***
Retirement wealth	0.012	0.004***	0.004	0.003
Retirement wealth squared	0.000	0.000	0.000	0.000
Work experience	-0.033	0.022	0.002	0.012
Work experience squared	0.001	0.001	0.000	0.000
Marriage duration if married	-0.004	0.004	0.002	0.002
Number of children	0.002	0.047	-0.067	0.029**
Interaction: Female-married	0.218	0.128*	0.072	0.078
Interaction: Female-children	0.038	0.067	-0.043	0.042
Female	-0.035	0.116	0.041	0.069
Age	0.001	0.006	-0.041	0.011***
Age squared			0.006	0.002***
High school	0.485	0.086***	0.482	0.050***
Technical college	0.789	0.107***	0.981	0.067***
College	1.091	0.204***	1.264	0.146***
Unemployment rate	0.020	0.024	-0.011	0.014
Total employment (%)	12.158	1.063***	6.796	1.405***
Minimum wage (relative to vital wage)	-0.006	0.033	-0.004	0.020
Savings market size (%)	0.047	0.024**	0.003	0.015
Credit market size (%)	-0.063	0.021***	0.000	0.013
Savings per 1000 people	-0.765	0.186***	-0.040	0.119
Credits per 1000 people	0.310	0.103 ***	0.019	0.062
Bank offices per 1000 people	-21.236	1.138***	2.577	1.205**
Bank workers per 1000 people	1.562	0.352***	-0.145	0.254
Number of marriages	-0.032	0.126	0.053	0.079
College tuition	0.486	0.148***	0.293	0.095***
Gender ratio (male/female)	0.114	0.109	0.271	0.065***
Time trend	0.015	0.049	-0.056	0.031*
Missing: Education	0.999	0.313***	1.001	0.224***
Missing: Number of children	-0.096	0.228	-0.159	0.140
Missing: Marriage duration	-0.686	0.539	-0.033	0.266
Constant	-9.273	1.002***	-5.494	0.839***
Permanent Unob. Het	0.441	0.115***	0.132	0.070*
Permanent Unob. Het	0.781	0.163***	0.141	0.107
Permanent Unob. Het	0.400	0.115***	0.080	0.067
Permanent Unob. Het	-0.178	0.196	0.001	0.110
Time-varying Unob. Het	-0.483	0.156***	-0.099	0.088
Time-varying Unob. Het	0.184	0.156	0.164	0.093*
Time-varying Unob. Het	-0.739	0.160***	-0.425	0.083***

*, **, *** Significant at the 10%, 5%, and 1% levels.

Table A.6: Multinomial logit on housing status (relative to owners with no loan)

Variable	Own but paying		Renting		Using	
	Coeff.	St.Er.	Coeff.	St.Er.	Coeff.	St.Er.
Lagged contribution status: Mandatory contributor	0.357	0.076***	0.170	0.090*	0.025	0.058
Lagged contribution status: Voluntary contributor	0.277	0.112**	-0.132	0.152	0.024	0.097
Lagged default status: Chose default	-0.075	0.137	-0.067	0.167	-0.079	0.122
Lagged default status: Opted out of default	-0.060	0.106	-0.116	0.136	0.173	0.091*
Lagged housing status: Owner but paying	3.027	0.078***	0.352	0.148**	-0.327	0.125***
Lagged housing status: Renting	2.033	0.137***	4.143	0.111***	1.436	0.120***
Lagged housing status: Using	0.633	0.128***	1.235	0.115***	1.759	0.057***
Lagged voluntary savings: Within system	0.163	0.074**	0.096	0.104	0.068	0.080
Lagged voluntary savings: Outside system	-0.052	0.064	0.008	0.082	-0.061	0.060
Retirement wealth	0.019	0.004***	0.002	0.005	-0.013	0.004***
Retirement wealth squared	0.000	0.000***	0.000	0.000	0.000	0.000*
Work experience	0.015	0.015	0.025	0.019	0.006	0.012
Work experience squared	-0.001	0.000**	-0.001	0.001	0.000	0.000
Marriage duration if married	-0.002	0.003	-0.029	0.004***	-0.017	0.002***
Number of children	0.144	0.033***	0.080	0.041*	0.184	0.027***
Interaction: Female-married	0.495	0.091***	0.452	0.114***	0.230	0.079***
Interaction: Female-children	-0.008	0.045	0.021	0.058	-0.018	0.039
Female	0.041	0.087	-0.210	0.100**	-0.221	0.068***
Age	0.053	0.014***	-0.028	0.017*	-0.004	0.012
Age squared	-0.014	0.003***	0.004	0.004	-0.001	0.003
High school	0.470	0.056***	0.332	0.071***	0.041	0.048
Technical college	0.833	0.083***	0.508	0.110***	-0.199	0.089**
College	1.297	0.209***	0.974	0.260***	-0.118	0.246
Unemployment rate	0.056	0.016***	0.072	0.020***	0.014	0.014
Total employment (%)	0.782	1.618	1.457	2.205	7.804	1.191***
Minimum wage (relative to vital wage)	0.051	0.027*	-0.022	0.033	0.072	0.019***
Savings market size (%)	-0.087	0.019***	-0.042	0.024*	-0.085	0.014***
Credit market size (%)	0.114	0.017***	0.062	0.020***	0.076	0.012***
Savings per 1000 people	0.212	0.146	0.259	0.182	0.199	0.117*
Credits per 1000 people	-0.650	0.081***	-0.370	0.100***	-0.393	0.060***
Bank offices per 1000 people	-5.214	2.248**	1.679	4.008	-11.634	1.430***
Bank workers per 1000 people	0.758	0.327**	-0.185	0.458	0.882	0.245***
Number of marriages	-0.323	0.102***	-0.038	0.120	0.044	0.074
College tuition	-0.010	0.115	-0.061	0.137	0.020	0.084
Gender ratio (male/female)	0.103	0.105	0.068	0.115	0.196	0.066***
Time trend	-0.382	0.040***	-0.168	0.048***	-0.169	0.030***
Missing: Education	0.507	0.308*	0.506	0.377	-0.325	0.334
Missing: Number of children	0.376	0.178**	-0.089	0.209	0.122	0.148
Missing: Marriage duration	0.577	0.339*	0.626	0.342*	0.226	0.253
Constant	-3.303	1.062***	-1.562	1.352	-6.591	0.745***
Permanent Unob. Het	1.277	0.094***	1.191	0.115***	0.147	0.116
Permanent Unob. Het	0.125	0.127	0.100	0.161	-0.227	0.120*
Permanent Unob. Het	-1.720	0.181***	-0.997	0.133***	0.034	0.069
Permanent Unob. Het	-0.312	0.133**	-0.180	0.170	-0.059	0.105
Time-varying Unob. Het	0.014	0.111	0.043	0.134	-0.071	0.085
Time-varying Unob. Het	0.078	0.111	0.121	0.142	-0.028	0.098
Time-varying Unob. Het	0.001	0.092	-0.041	0.117	0.086	0.076

*, **, *** Significant at the 10%, 5%, and 1% levels.

Table A.7: Multinomial logit on family characteristics

Variable	Marital status (relative to single)		Children variation (relative to no change)			
			Decrease		Increase	
	Coeff.	St.Er.	Coeff.	St.Er.	Coeff.	St.Er.
Work experience	0.016	0.015	-0.021	0.020	-0.016	0.033
Work experience squared	0.000	0.001	0.000	0.001	0.001	0.001
Marriage duration if married	-0.026	0.004***	0.081	0.006***	-0.084	0.014***
Married	-4.324	0.106***	-1.550	0.156***	0.582	0.182***
Number of children	-0.251	0.035***	1.795	0.053***	0.668	0.076***
Interaction: Female-married	-0.076	0.105	-0.317	0.127**	-0.030	0.197
Interaction: Female-children	0.106	0.048**	0.340	0.071***	-0.043	0.092
Informal worker	-0.055	0.118	0.255	0.125**	0.431	0.253*
Not working	-0.146	0.114	-0.070	0.118	0.327	0.245
Female	0.398	0.089***	0.073	0.132	-0.026	0.180
Age	0.004	0.012	0.662	0.021***	-0.094	0.029***
Age squared	-0.001	0.003	-0.140	0.005***	-0.006	0.010
High school	0.021	0.060	-0.127	0.065**	0.197	0.105*
Technical college	-0.047	0.092	-0.097	0.109	0.045	0.167
College	-0.403	0.160**	0.111	0.179	0.012	0.300
Number of marriages	-0.279	0.077***				
Gender ratio (male/female)	0.034	0.684				
College tuition			-0.075	0.053	-0.161	0.078**
Time trend	0.045	0.018**	0.126	0.020***	-0.134	0.033***
Missing: Education	-0.271	0.306	0.112	0.373	0.798	0.589
Missing: Number of children	-0.642	0.156***				
Missing: Marriage duration	-0.120	0.417	1.840	0.538***	0.206	0.883
Constant	3.097	0.766***	-10.145	0.309***	-1.591	0.326***
Permanent Unob. Het	-0.302	0.103***	-0.013	0.105	0.480	0.209**
Permanent Unob. Het	-0.147	0.147	0.080	0.176	-0.179	0.331
Permanent Unob. Het	-0.090	0.097	0.215	0.101**	0.204	0.222
Permanent Unob. Het	-0.048	0.113	0.108	0.148	-1.092	0.426**
Time-varying Unob. Het	0.318	0.181*	-1.157	0.180***	-1.103	0.419***
Time-varying Unob. Het	-0.044	0.134	-11.288	0.979***	-1.709	0.518***
Time-varying Unob. Het	0.127	0.156	0.167	0.122	-0.511	0.325

*, **, *** Significant at the 10%, 5%, and 1% levels.