Life Cycle, Financial Frictions and Informal Labor Markets
The Case of Chile

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Life Cycle, financial frictions and informal labor markets The case of Chile[1]

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Abstract

In this paper we study the implications of economic policies that affect household's income. We focus on Chile after the massive demonstrations against the existing standard of living observed in 2019. Using a search model with life-cycle features and survey data, we found that an equivalent change in labor tax rates and non-contributary pensions have opposite effects on labor markets, specifically on informality and unemployment duration. Non-contributary pensions offers a milder trade-off as it produces a second order increase in informality. However, due to the presence of informal labor markets and financial frictions, non-retired agents increase their current consumption only after a tax cut. That is, in this framework, a positive wealth shock can reduce consumption. Thus, when we take into account the impact on welfare, as households are assumed to value only consumption, cutting taxes seems to be preferred. We characterize labor market and consumption-savings decisions. We found 2 effects operating simultaneously and in opposite directions: substitution and wealth. Due to the presence of risk averse agents and incomplete capital markets, the latter prevails suggesting that the life cycle aspects of the labor market are critical to understand policy trade-offs.

Keywords: search models, life-cycle, simulation-based estimation, social-security reform.

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1. Introduction

In late 2019 Chile was hit by a series of violent demonstrations triggered by a minor increase in the cost of public transport. The contrast between the mild cause and the drastic consequence suggests that those riots were generated by other, deeper, factors. After surveying the Chilean population the literature (see for instance Zuñiga, 2019) noticed the main factors behind the protests: i) pensions were considered insufficient and ii) the cost of living was said to be too high.

Among the most direct instruments to tacle those problems we found labor taxes and non-contributory pensions. However, the aggregate impact of these instruments is far from being clear, especially in an incomplete markets framework with informal labor markets. Measuring these impacts will allow policy makers to properly asses the underlying trade-offs and shed some light on the interaction between employment decisions, savings and contributions to social security, which is probably one of the key concerns in the design of pension systems and labor market regulations in Emerging Markets. From a purely fiscal perspective, reforms in any of those two institutions may have complex effects on decisions to be formally employed, which also has important effects on the sustainability of the pension system. We focus on Chile mainly for 2 reasons: first, given the lower level of informality in this country (see Gasparini and Tornarolli, 2009), these policy instruments seem relatively effective when compared to other Latam countries. Second, as Chile has a full capitalization system, the life cycle aspects are critical to measure the labor market impact of any reform.

Using a search model with life-cycle features and data from Chile, included in the Harmonized Longitudinal Social Protection Survey (LSPS), this paper finds that tax rates and non-contributary pensions have differentiated effects on labor markets. We compute equivalent policies in terms of present value. We found that a tax cut generates a reduction in informality (henceforth IR) but rises unemployment duration (UD). A hike in non-contributary pensions causes the opposite effects *but offers a milder trade-off as it produces a second order effect on informality.* However, due to the presence of informal labor markets and financial frictions, non-retired agents increase their current consumption only after a tax cut. *Thus, when we take into account the impact on welfare, as by assumption households only obtain utility from consumption, cutting taxes seems to be preferred.*

From a qualitative perspective, we can sharply characterize labor market decisions. We found 2 effects operating simultaneously: substitution and wealth. Due to the presence of risk averse agents and incomplete capital markets, the latter is responsible for the trade off between IR and UD. The wealth effect is associated with the discounted value of income when retired, which has a different quantitative impact depending on the state of the agent. Moreover, this effect implies that after any proposed policy shock the value of being unemployed changes in the same direction as the value of being empleoyed, in any market, but is the least sensible among them all. Thus the ratio of accepted offers move in opposite direction with respect to the duration unemployment, generating the observed behavior.

The above paragraph suggests that the life cycle aspects of the labor market are critical to understad policy trade-offs. Moreover, the wealth effect, in the presence of liquidity constraints, can also account for the decrease in current consumption after a hike in non-contributary pensions. As agents move to informal labor markets, because the value of a formal job offer relatively decreases after the shock, there is a reduction in current income which can not be compensated with debt even tough the agent is wealthier. Thus, expenditures and savings goes down after the shock; a fact that makes taxes preferred to transfers. *That is, in this framework, a positive wealth shock can reduce consumption.*

From a methodological point of view, the paper estimates some of the parameters of the model using a simulation-based structural econometric method and calibrates the rest of them. Proposals for *future* reforms that have never been implemented in Chile cannot be properly addressed using reduced-form-based techniques (i.e. RCT) since exogeneous variability in a given data set is not available. In this sense, the results in this paper suggest that the observed rigidity in the informality rate in Latam (see for instance Gasparini and Tornarolli, 2009) is a consequence of demand side problems as employees respond elastically to several policy stimulus. Moreover, the model is used to obtain the effects of specific policy reforms through simulation methods. In this way, we provide a clear way to understand the possible mechanisms behind policy changes, complementing what may be found later on through RCT's methods.

Finally, this paper develops a search model with life-cycle elements to quantitatively analyze the consequences of policy reforms using the Chilean data from the Longitudinal Social Protection Survey (LSPS) harmonized database. We model the life cycle of a worker. The first two thirds of her life she is active in the job market and the last one she is retired. During the period of active life, the model captures the presence of two types of labor markets: formal, characterized by the presence of contributions to social security, and informal. Thus, we provide key statistics to identify reservation wages in a non-stationary search model with risk averse agents and incomplete markets. In order to compute the parameters of the model, this paper combines a simulated-method-of-moment approach with the more traditional calibration technique. We use three moments from the database: the average unemployment duration and the coefficient of variation of consumption for both active workers and retired agents. We use these moments to estimate two parameters, the probability of: i) losing a job for an employed worker, ii) receiving a new offer for an unemployed agent. The probability of being fired is slightly above (but within range) the values in the search literature. The rest of the parameters are calibrated, most of which use official information from the Chilean pension regulator, or pinned down using an ad-hoc value as benchmark depending on the limitations found in the data set.

1.1. Relation with the literature

This paper contributes to two brands of literature. The first is that on job-search models with life-cycle elements. Examples of this literature are Low et al (2010), Piguillem et al (2012), Michelacci and Ruffo (2015) and especially Cirelli et al (2017). In those papers wages are assumed to follow a deterministic path or otherwise directly being a constant. This paper keeps the random nature of wage offers more traditional in search models, among other reasons, to analyze more in depth the role of changes in reservation wages in the mechanisms behind policy reforms. To our knowledge, that mechanism has not been exploited in those models. Of course, given the assumption of risk-averse workers, computing the reservation wage is far from being trivial given its dependence on asset holdings[4] and the life-cycle assumption. This is also one of the assumptions imposing constraints on the possibility of estimating parameters using simulation-based methods given the well-known curse-of-dimensionality problems.

The paper also provides a contribution to the search literature that considers informal labor markets. The latter include the work by Bosch and Esteban-Pretel (2012, 2015), Meghir et al (2015) and Flórez (2017). The papers by Bosch and Esteban-Pretel and Meghir et al (2015) include the demand side of labor markets through a matching model, although they all abstract from savings and retirement considerations that are central in this paper. Flórez (2017) does consider savings in a search model with an informal sector, although it ignores retirement and life-cycle elements. In this regard, this paper is a good complements of those four articles providing a focus on the interaction between formal versus informal labor-markets and retirement savings, an issue not addressed before in that literature.

The rest of the paper is as follows. Section 2 presents the search model. Section 3 presents the data sources and the estimation-calibration methods. Section 4 presents the result of the estimation and calibration of parameters. Section 5 presents the results of the policy exercises. Finally, section 6 concludes.

2. A life-cycle search model with non-segmented labor markets

This section introduces the search model. The first subsection presents the set-up, while the following subsection presents some features that arise from the solution of this model.

2.1. The set-up

Consider an infinite horizon economy with discrete time periods. The model considers an agent[5] whose age is counted in semesters (half years). Let $t = 0, 1, \ldots T$ denote the time-periods in which that agent may work, depending on the job opportunities encountered. Let $t = T + 1, \ldots, T + \tau$ be the semesters of retirement for the agent until her death at age $T + \tau$. This model assumes that all these terminal dates

[4] This problem goes back to the well-known analysis by Danforth (1979) and subsequent work.

[5] Just as a convention we use the term "she" to refer to the agent in the subsequent paragraphs.

are known with certainty at the very beginning of her life. This assumption allows higher feasibility for the estimation procedure.

The agent's preferences can then be represented by an expected utility function depending on each period consumption, c_t. The Bernoulli (per-semester) utility function with respect to consumption is $u(c_t) = \frac{c_t^{1-\sigma}}{1-\sigma}$. The model assumes a discount factor per month equal to a constant β, which lies in the open segment (0,1).

For all periods $t = 0, 1, \ldots T$ the agent can be either unemployed or else employed in a job. The assumption is that there are two types of employed agents, who, when unemployed, may find one of two possible types of job opportunities with certain probabilities. The two types of potential jobs are a formal employment and an informal employment. Characteristics of each type of jobs are presented below. For unemployed agents search frictions, imply that obtaining a new job opportunity of either type occurs with a probability α, while with the remaining probability the agent remains unemployed. When receiving an offer the probability that the latter is a formal type is equal to p, while with the remaining probability the offer received is of an informal type. The formal job is characterized by a certain gross wage w^f, subject to tax rate equal to τ. The amount paid by the worker is her contribution to a pension fund, as it is the case in countries like Chile. For then other worker type the informal job is characterized by a tax-free wage w^I.

Unlike other structural models that include the labor demand side (whose information is not available in the (harmonized) LSPS database), and where the formality decision comes from an implicit bargaining process with employers,[6] here wage realizations are assumed as exogenous with finite support. Let $\{w^I_{(1)}, w^I_{(2)}, ..., w^I_{(K)}\}$ be the support of w^I and let $\{w^F_{(1)}, w^F_{(2)}, ..., w^F_{(K)}\}$ be the one for the gross formal wage w^f. The probability of each possible wage realization is denoted as π_w. Each type of employed agent keeps her job the following period with respective probabilities δ^f and δ^I, and lost with the respective remaining probabilities. When loosing the job the agent remains at least the period when fired as unemployed.

In every period, the agent (either before or after retirement) has available a savings technology, which can be empirically interpreted as a bank account or cash. Such savings technology yields a constant (real) gross per-period return equal to R.[7] For future reference, we denote as a_t the level of savings that the agent decides in date $t-1$ for the next date t. On the other hand, when an agent is formally employed, all her contributions are recognized as a pension payment after retirement. The yield on these contributions is known at the time of the contribution.[8]

Finally, after retirement, social security pays an amount additional to the contribution-yield transfer, which is viewed as the non-contributory branch of the retirement payments. These non-contributory pension payments are assumed to be lump-sum.

2.2. Bellman equations

Under the assumptions presented in the first part of section 2 it is possible to write the Bellman equations for the agent when retired and before retirement.

- Retired agents

Suppose that retired agents know that contributions yield a stream of transfers T_t in date t, with t larger than T. Thus, the appendix shows that the Bellman equation for retired people is simply:

[6] See Bosch and Esteban-Pretel (2012, 2015) as examples of these types of matching models with endogenous informality decisions through bargaining.

[7] This is clearly a convenient assumption for computation-estimation purposes.

[8] This assumption is clearly made for computational and estimation purposes. The life-cycle intrinsic feature of this model makes policy functions non-stationary in a recursive sense. This introduces several computing complexities that threaten the feasibility of using any type of structural estimation methods. This is the main reason for excluding possibly more realistic assumptions regarding knowledge on the yield on retirement fund contributions.

$$V_t\left(Ra_t,\mathbf{T}_t,\mathbf{T}_{t+1},\ldots\right)=\max_{a_{t+1}}\left\{\frac{\left(Ra_t+\left(T_t+T_t^{NC}\right)-a_{t+1}\right)^{1-\sigma}}{1-\sigma}+\right.$$

$$\left.\beta\Phi_t(R,\beta,\mathcal{T})\frac{\left(R^{\mathcal{T}-t}a_{t+1}+\sum_{S=t}^{12T}R^{12\mathcal{T}-s}\left(T_S+T_S^{NC}\right)\right)^{1-\sigma}}{1-\sigma}\right\} \quad (3)$$

where:

$$\Phi_{\mathcal{T}}(R,\beta,\mathcal{T})=\frac{1+\beta(\beta R)^{\frac{1-\sigma}{\sigma}}}{\left[R+(\beta R)^{\frac{1}{\sigma}}\right]^{1-\sigma}},$$

$$\Phi_t(R,\beta,\mathcal{T})=\frac{1+\left(\beta R^{(\mathcal{T}-t)(1-\sigma)}\right)^{\frac{1}{\sigma}}\Phi_{t+1}(R,\beta,\mathcal{T})}{\left[R^{\mathcal{T}-t+(\beta R^{\mathcal{T}-t-1})^{\frac{1}{\sigma}}\Phi_{t+1}(R,\beta,T)}\right]}$$

Here the variable T_s refers to the income received from pension funds, while T_s^{NC} refers to the non-contributory side of social-security payments. The value function corresponding to the very first period of retirement is equal to:

$$V_T\left(Ra_T,\sum_{s=0}^{T}R^{T-s}T_s\right)=\frac{\left[Ra_T+\sum_{s=0}^{T}R^{T-s}\left(T_s+T_s^{NC}\right)\right]^{1-\sigma}}{1-\sigma}\Phi_T(R,\beta,\mathcal{T}) \quad (4)$$

The just-retired agent knows the total yield $\sum_{s=0}^{\mathcal{T}}R^{\mathcal{T}-s}T_s\equiv Y$with certainty at the retirement date T. How this same agent considers this variable before retirement is presented next, together with the Bellman equations for her when active in the labor market. The last expression taken ex − post constitutes the whole amount of funds from which contributed pension payments are taken after retirement. The model assumes that, at least for countries where the majority of formal workers contribute to a funded system then the amount of such payment is just the pro-rata fraction of all those accumulated funds:

$$T_t=\frac{Y}{\mathcal{T}-T},t=T+1,...,\mathcal{T}$$

For countries with pay-as-you-go systems such as Uruguay, the amount of contributed-pension payments is tied to a reference value with additional amounts usually tied to the number of periods with positive contributions to the system. This is clarified below after presenting the problems of active workers.

- The agent's problem(s) before the retirement

We first start presenting the pre-retirement perception of post-retirement yields of the |contributed side of pension payments. In the case of a country with fully-funded system, the non-retired agent perceives Y as follows:

$$Y=\sum_{s=0}^{T}\rho^s\theta_s\tau_s w_s^f 1_s \quad (5)$$

where 1_s is an indicator function taking on the value of 1 in every period s when the agent is formally working at the formal wage w_s^f. In equation (5), the total amount of funds coming from contributions consists in the capitalized value of all contributions (each of which consists in the product of the formal wage w_s^f multiplied by the net-capitalization factor θ_s).

This information allows writing a Bellman equation for active workers, one for each employment status, given an education level denoted as h. If in a given date t, the agent is unemployed then:

$$V_t^U\left(Ra_t, Y_t\right) = \underset{a_{t+1}}{\text{máx}}\left\{\frac{\left(Ra_t + b - a_{t+1}\right)^{1-\gamma}}{1-\sigma} + \alpha\beta\left\{p\left[\sum_{w_{t+1}^f} \text{máx}\left\{V_{t+1}^f\left(Ra_{t+1} + (1-\right.\right.\right.\right.\right.$$

$$\left.\left.\left.\tau_{t+1}\right) w_{t+1}^f; Y_{t+1}\right); V_{t+1}^U\left(Ra_{t+1}, Y_t\right)\right\} \pi_{w_{t+1}}^f\right] + (1-p)\left[\Sigma_{w_{t+1}^I} \text{máx}\left\{V_{t+1}^I\left(Ra_{t+1} + \right.\right.\right.$$

$$\left.\left.\left.\left.\left. w_{t+1}^I; Y_t\right); V_{t+1}^U\left(Ra_{t+1}, Y_t\right)\right\} \pi_{w_{t+1}}^I\right]\right\} + \beta(1-\alpha) V_{t+1}^U\left(Ra_{t+1}, Y_t\right)\right\} \quad (6)$$

In equation (7) the variable V_{t+1}^f denotes the value of becoming formally employed in the next period, while V_{t+1}^I denotes the value of becoming informally employed. The term Y_t denotes the total perceived value at time of retirement of the yield on contributions (according to equation (5)), up to period t. The law of motion is:

$$Y_{t+1} = Y_t + 1_t^f \theta_t \tau_t w_t^f \tag{7}$$

For the formally employed at period t the Bellman equation is simpler:

$$V_t^f\left(Ra_t + \left(1-\tau_t\right) w_t^f; Y_t\right) = \underset{a_{t+1}}{\text{máx}}\left\{\frac{\left(Ra_t + \left(1-\tau_t\right) w_t^f - a_{t+1}\right)^{1-\sigma}}{1-\sigma} + \left[\beta\delta V_{t+1}^f\left(Ra_{t+1} + (1-\right.\right.\right.$$

$$\left.\left.\left.\tau_{t+1}\right) w_t^f; Y_{t+1}\right) + \beta(1-\delta) V_{t+1}^U\left(Ra_{t+1}, Y_t\right)\right]\right\} \tag{8}$$

while for the informally employed the Bellman equation is similar

$$V_t^I\left(Ra_t + w_t^I; Y_t\right) = \underset{a_{t+1}}{\text{máx}}\left\{\frac{\left(Ra_t + w_t^I - a_{t+1}\right)^{1-\sigma}}{1-\sigma} + \left[\beta\delta V_{t+1}^I\left(Ra_{t+1} + w_t^I; Y_{t+1}\right)\right.\right.$$

$$\left.\left. + \beta(1-\delta) V_{t+1}^U\left(Ra_{t+1}, Y_t\right)\right]\right\} \tag{9}$$

The terminal condition for any of these value functions at the month previous to retirement (period $T-1$) is common to all of them. Let y_{T-1}^e be the (net-of-tax) income in that period. Then the corresponding Bellman's equation for any employment state e is:

$$V_{T-1}^e\left(Ra_{T-1} + y_{T-1}^e; Y_{T-1}\right) = \underset{a_T}{\text{máx}}\left\{\frac{\left(Ra_{T-1} + y_{T-1}^e - a_T\right)^{1-\sigma}}{1-\sigma} + \right.$$

$$\left.\beta\Phi_T(R, \beta, \mathcal{T})\frac{\left[Ra_T + \sum_{S=0}^{T} \rho^s \theta_s \tau_s w_S^f 1_s + \sum_{s=0}^{12T} R^{J-s} T_s^{NC}\right]^{1-\sigma}}{1-\sigma}\right\} \tag{10}$$

The last expressions assumes that the agent correctly perceives that the amount of payments after retirement is proportional to the total capitalized value of contributions while working (in the formal labor market). Again, the paper makes this assumption to facilitate computation feasibility, which is a key requirement for estimation purposes. As it will be stated in the last section, possible future research may generalize this simple assumption.

3. Data and estimation procedure

This section contains a description of the Longitudinal Social-Protection Survey (LSPS) and some other official data sources used to take the model to the data. Moreover, we describe the methodology used to estimate, calibrate and simulate the model. Addiotional details can be found in the appendix.

3.1. Description of the data set

This paper uses the harmonized database from the Longitudinal Social-Protection Survey (LSPS). Such database is based on national surveys from five countries: Chile (for which there are two years included here, 2006 and 2009), Colombia (year 2012), Paraguay (2015), El Salvador (2013) and Uruguay (2013). Each observation corresponds to an interviewed person from a household in a given country for the year in which the survey was performed. For some of the variables there is retrospective information, while for the Chilean case the presence of two waves allows for a more complete longitudinal dimension in the variables included.

The harmonized database includes information on social security characteristics such as whether the interviewed person receives a contributed pension or a non-contributory pension, or is retired, and if so, the amount of income received from retirement pensions. Another variable informs whether the interviewed person, given that she or he is an active worker, contributes to the formal retirement pension system. This information is key to trace a link between the forma-informal dimension in the model and its empirical counterpart. Below is an explanation for how this link is done in this current version of the paper.

The database includes also labor-market variables (current and past employment status, unemployment duration), income-related variables, education variables and demographic information, including age and sex. Income information does not come at the individual-level precision. Rather, for each observation then income level reported is the meanvalue of the income corresponding to the quintile at which the observation belongs. That is, the income reported for an interviewed person i that belongs, say, to the second quintile, is the mean-income of the second quintile. The same happens to the information on expenditure, with the difference that the database provides five different categories of those expenditures. Given that the model only considers a unique consumption good, the paper aggregates the five expenditures component by adding them up. Proceeding in this way, the resulting “aggregate” expenditure has a more disperse and wider support than each of the five expenditure components. Thus, this version uses this information on expenditures for the estimation-calibration stage of some of the parameters, to be described in the subsection below.

Across all countries included in the Survey, the paper only uses the Chilean data. There are three main reasons for this choice. The first is that it constitutes the Latin American country with the most mature privately-funded pension system in the sub-continent. Although subject to several recent criticisms from different political actors, the Chilean system still now is highly valued by specialists.

Second, the model in this paper is more suitable for a “fully-funded system” like the one in Chile, at least concerning the contributions from formal jobs, rather than more mixed contributory-pension systems.

The third reason is that there is accurate information for variables not covered in the survey such as tax rates and other variables for Chile, while for other countries in the Survey the availability of the same variables is more doubtful. Such information directly comes from public sources,[9] and it is information necessary to complete the calibration of parameters in the model.

3.2. Quantitative methodology

This subsection describes the methodology followed in this paper, both for estimating – calibrating the model parameters and for policy exercises. It first starts with a brief review on the literature and then it specifies a rationale for the method chosen in this paper.

[9] See, e.g., https://www.spensiones.cl/portal/orientacion/580/w3-propertyvalue-6138.html.

A large fraction of the empirical literature on search models uses ML-based methods.[10]That literature exploits both the risk-neutrality assumption of the standard model and longitudinal data on unemployment duration to construct likelihood functions that can be used for estimation. Yet, with risk-averse workers, this task becomes much more cumbersome, mainly because of the unavailability of exact closed-form solutions for the likelihood function in such cases. Papers like Lentz (2009) use a numerical approach to compute policy functions embedding the latter into more analytical likelihood functions.[11] Availability of higher frequency data may limit the application of ML methods in highly non-linear search models. The latter is particularly applicable to this paper, given the use of a Survey with low-frequency data.

In contrast, other recent empirical literature with search models focuses on simulation-based methods[12]. Several recent papers estimating structural search models[13], including some assuming risk-averse workers such as Lise (2013), Haan and Prowse (2017), use different variants of those methods whose common origin goes back to the simulated methods of moments (SMM) proposed by Mc Fadden (1989) and Pakes and Pollard (1989). The typical SMM procedure starts using simulated data. Then the method uses an algorithm to minimize a weighted distance between the sample moments of the selected variables and the moments implied by the model for given values of the parameters.[14]

This paper uses a mix of SMM-based estimation and calibration procedures to quantify the parameters. The type of data available prevents the use of ML-based methods. On the other hand, the task of estimating parameters on a life-cycle, highly non-linear model also imposes constraints on the exact number of parameters to be estimated through SMM, forcing to calibrate the rest of the parameters. The reason for this limitation is that those two features of the model here introduce serious computation-feasibility concerns, which at the same time implies a compromise on the feasibility of estimating all parameters through SMM. It is then useful also to review the computation issues of this type of models.

Computation in this context is important for two reasons. First, as mentioned above, a feasible numerical strategy is the first step towards the estimation of empirically meaningful parameters. Second, one of the main purposes of working with structural search models is to perform counterfactual policy exercises. Even if we don't have exogeneous variability in the date set, the structual estimation of deep parameters remains a feasible choice. Thus, the literature on empirically-oriented labor search model emphasizes this role as the main value-added of those models relative to more reduced-form approaches.

There is a well-known literature on numerical dynamic programming applied to discrete choice models[15] that highlights important computational problems generated by search models, mostly related with the sensitivity of reservation wages with respect to endogenous variables. In order to circunvent these issues, the strategy here is to use the non-stationarity of the value function inherited from the finite horizon dynamic programming problem to capture in full the flexibility of reservation wages (and its dependence on wealth and policy variables), isolating the simulated methods of moments from these type of variability which in turn allows to estimate the (time invariant) deep parameters.

The methodology entails obtaining the optimal policy-functions (where the optimality is at the individual level) computed over a finite grid of points corresponding to the state variables: wages (or, else, the unemployment-benefit parameter) and assets. Given the life-cycle nature of the model here, there is a large degree of heterogeneity coming from the age profile. This may introduce a typical curse-of-dimensionality problem that appears in these dynamic models.

In this paper however, the structure of the data set implies a natural solution to these problems as the support in the observed distribution of wages is very coarse. In particular, given how income information comes from the LSPS, this support has only five elements. Each of them is linked to a particular quintile

[10]For a survey on that methodology see, e.g., Eckstein and van den Berg (2007).

[11]Launov and Walde (2013) proceeds in a similar way but using a model with risk neutral workers estimated for the German case.

[12]For an early survey on simulation-based estimation methods see Stern (1997). For a more recent survey see Aguirregabiria and Mira (2010).

[13]For example, Yamaguchi (2010), Meghir et al (2015).

[14]Recently, Eisenhauer et al (2015) compare both ML and SMM type of estimation methods in occupational choice models thorough Monte Carlo simulations. Although SMM performed reasonably well in several dimensions, that paper shows that ML methods tend to more generally present the same or better properties.

[15]For surveys on numerical dynamic programming and computational issues see, e.g., Rust (1997) and Judd (1998). Some papers propose several algorithms to overcome such problem. See, e.g., Keane and Wolpin (1994).

of the income distribution within the Survey. More to the point, the asset grid is also coarse enough to avoid this dimensionality problem.

As regards the value of estimated parameters, this paper follows state of the art quantitative models with labor-search and risk-averse workers.[16] A well-known contribution is Lentz (2009). This paper estimates a search model with risk-averse workers, based on Lentz and Tranaes (2005), applied to Dutch weekly data. Lentz (2009) uses Dutch data on unemployment spells to eventually estimate a hazard rate for active workers. In the case of this paper, the Survey provides information about months being unemployed during a whole year for each worker, which allows us to recover the duration of unemployment.

We can estimate but not observe the probability of being fired, $1 - \delta$ and the probability of getting a job offer, α. The LSPS database provides information on whether during the year before the interview took place the person was employed and it reports if in the year of the interview she was unemployed. Yet, there is no information neither about when a worker lost her job between semesters within a given year nor receive a formal/informal job offer.

For the identification and estimation of those two parameters, then, this paper uses an indirect approach, based on the information about income and expenditures, together with the duration of unemployment.[17] The paper computes the coefficient of variation of consumption (expenditures) for active workers and for retired people, according to the information in the Survey. Then, we use those two coefficients together with the average observed duration of unemployment to identify and estimate the probability of finding a new job for an unemployed worker and the probability of being fired. The estimation is done using the simulated method of moments. The paper uses an overidentified version of the method.

At first glance it may seem odd the use of the coefficient of variations on consumption to identify and estimate parameters related to job creation or job destruction. Yet, there is a rationale behind this use. Suppose two different values for this coefficient. Given a value for the variance of wages, and given the borrowing constraint assumed in the model, what lies behind the agent facing higher coefficient of variation of consumption is that she must be more liquidity constrained relative to the agent with lower consumption variation. This implies that the former accumulated a lower amount of assets and then her reservation wage is lower than for the latter. Ceteris paribus the rest of the conditions in the model, the agent that hits more frequently the liquidity constraint should generate a shorter duration of unemployment than the other agent. If the observed duration does not decrease in the data set, then one possible way to make all these features consistent is that the probability of receiving a new job offer for an unemployed worker, α, should be lower and/or the firing probability, $1 - \delta$, should be higher.

The rest of the parameters are calibrated directly from the public web-pages with official information on contribution rates, unemployment benefits and contributed and non-contributed pension payments (for retired agents). Further, the fraction of total tax payments devoted to the contributed pension system and the return on contributions to future pensions is also identified from public information about the return on chilean pension funds.

Finally, this paper does not intend to identify and calibrate (or estimate) preference parameters (risk aversion and discount factor). The reason is that the Survey does not provide information on asset accumulation, together with the fact that the expenditures information is already used to identify and estimate the two labor-market related parameters referred in the paragraphs above. Thus, the values for those two preference-related parameters are set to standard values in the related literature (both from labor search and from Macro papers).

[16] A more complete survey on identification in models of labor markets see French and Taber (2011).

[17] Regarding the wage probability distributions, several papers in the search literature such as, e.g., Lise (2012) and Low et al (2010) estimate a wage equation by running auxiliary regressions using panel data with monthly or weekly frequency. Lentz (2009) however explains that such strategy may explain too little of the wage variation. Given the type of wage (income) data in the LSPS, the probabilities of realizations are directly calibrated from the relative frequency for each of the five realizations in the Survey.

4. Results I: structural estimation and calibration

This section reports results concerning the estimation and calibration of deep parameters. Table 1, presented below, shows the three moments that are used to estimate the probability of receiving a job offer, α, and the probability of being fired, $1-\delta$.

Table 1: Moments used in the estimation procedure Computed using the LSPS	
Moment	Value
Average Duration of Unemployment in Semesters	1,5
Variation coeff of consumption, active workers	0,15
Variation coeff of consumption, retired	0,43

Source: own calculation from LSPS database

The table includes the average duration of unemployment, computed as the number of months that a worker remains unemployed in the last twelve months, the coefficient of variation of aggregate consumption for active workers and retired agents. As stated in the last section, for other parameters we use information from official Chilean sources.

Table 2 below presents the values of the parameters which are estimated and calibrated. Estimations are obtained using the SMM and the moments reported in Table 1. The calibrated values for wages are obtained directly from the LSPS data. The return on pension funds and the unemployment compensation are obtained from the Chilean social-security authority web-site. The tax rate on wages is obtained from the OECD. The interest rate is obtained from official statistics.

Table 2. Parameters Estimation comes from matching moments that appear in table 1. Calibration is done using official data sources			
Parameter	Description	Value	Method
$1-\delta$	Layoff probability	0,068	Estimated through SMM (*)
α	Probability of receiving a new offer	0,535	Estimated through SMM (*)
p	Probability of a formal offer	0,5	Assumed
π_w	Probability vector of each wage	[0.14 0.21 0.20 0.24 0.21]	Calibrated from LSPS
θ	Compulsory savings	0,9	Calibrated from public source
ρ	Maximum return on pension funds	0,045	Calibrated from public source
τ	Tax on wages	0,1	Calibrated from public source
$R-1$	Net interest rate	0,03	Calibrated from public source
b	Unemployment compensation	0,7	Calibrated from public source
β	Subjective discount factor	0,95	Reproduced from literature
σ	Relative risk aversion	3,0	Reproduced from literature
(*) For this joint estimation the standard error is 0.0893			
Sources: own estimation and calibration based on harmonized LSPS data, OECD, Superintentendencia de Pensiones Central Bank (Chile).			

The estimated value of the firing probability is 0.068. This value is within the order of magnitudes relative to other estimates in the literature.[18] In fact, it is often slightly above those other estimates with few exceptions. Clearly, a straight interpretation of these differences in estimated values is that at least for the Chilean case (and presumably for other LAC countries) jobs in the "averaged" labor market (between formal and informal) may be slightly less secure than their counterparts in more developed countries, as ex-ante expected. Of course, this is due to a more de-regulated institutional framework.

[18]For example, Paserman (2008) gets a range of estimates for a similar parameter between 0.0087 and 0.011. Yamaguchi (2010) obtains a separation probability of 0.04 for workers with college education and 0.077 for workers with only high-school education. Low et al (2010) calibrates those two probabilities in 0.028 and 0.049 respectively.

On the other hand, the probability of finding a new job opportunity (of any kind) is estimated in 0.535. Comparing this with other results in the literature, this value is within the estimated bounds.[19] Of course, the estimated value of this parameter is affected by the assumed values for the probability of the offer being formal, p. This paper assumes a benchmark value of 0.5. Although this looks too simple, it assumes a value that facilitates the simulation-based method used in this paper. Finally, at the bottom of Table 2 appears the standard error of the joint estimation of those two parameters, equal to 0.0893.

The following eight rows of table 2 report the calibrated values of three parameters related to formal workers: the tax rate on formal wages, the fraction of tax payments included for future retirement payments, and the (implicit or explicit) return on pension funds. As stated above, the web-page from the Superintendecia de Pensiones[20] provides information on several of those parameters such as the rate applied from labor income as the contribution to the pension fund. The return on funds comes also directly from the report of the above-mentioned website. The value of the fraction of total tax payments going to retirement funds is set to 90 % to take into account fees and other deductions.

The value of the real interest rate on savings is calibrated from the average real interest rate on deposits reported from the official Chilean statistics. Ideally, the relevant calibration should include possibly other returns from other investment options, depending on the qualitative information found in LSPS on the types of investment that the interviewed person reports to have. Yet, given that such information is only qualitative, it is not possible to compute weighted averages of rates of return from the LSPS database.

The next row reports the calibrated value of the unemployment benefit, equal to 0.70. It corresponds to its normalized value according to the official information from the social security Chilean web site. In fact, the payments corresponding to such benefits are decreasing in the duration of unemployment, a feature that is not present in the paper. It is always possible to add this assumption to the model. However, this generalization implies a heavy cost in terms of the computability of the model given the non-linearity of the utility function and the non-stationarity of the dynamic programming problem.

Finally, the last two rows present the values of the main two preference parameters. As stated in the section above, this paper uses values for those parameters directly taken from those found in the international literature.

Table 3 presents some quantitative properties of the calibrated-estimated benchmark model. The table reports the results obtained after simulating the model for five endogenous variables. Moments are taken across semesters of active life. The second column reports the results using data while the third does so running simulations. Averages and standard deviations are taken within the agent's first fifty years of life.

Table 3: Properties of the benchmark model.

Selected moments computed using simulated and actual data.

Variable	Data	Model
Average duration of uneployment (in semesters)	1,15	1,76
Coefficient of variation of consumption - active	0,15	0,24
Coefficient of variation of consumption - retired	0,43	0,4
Frequency of accepted formal job offers	-	0,81
Frequency of accepted informal job offers	-	0,35

Source: own computations based on simulated and LSPS data

The first three rows of Table 3 report statistical moments for the three variables used to estimate the model. The main purpose of these reported statistics is to provide a measure of the precition of the match of the model.

As regards the match of the model, the difference between the observed and predicted unemployment duration does not look large. Indeed, the model overestimates the observed figure in less than 18 %. The

[19] For example, comparing this value with the estimates in Paserman (2008) the latter predicts a range of offer probabilities from the estimated parameters in that paper, where the upper bound for that range is 0.562 for workers receiving high-wage offers in the first week of unemployed, a similar value to that estimated in this paper. On the other hand, the value used in Low et al (2010) is slightly higher than in this paper (0.76 for low-education workers, 0.82 for high-education workers).

[20] See https://www.spensiones.cl/portal/orientacion/580/w3-propertyvalue-6138.html.

model also overestimates the coefficient of variation for active workers's consumption by 7 percentage points. This seems a weakness of the estimation method. Yet, part of this problem is attributed to the fact that the intertemporal consumption problem of the retired agents is assumed to be non-stochastic. Indeed, the last row of table 3 shows that the model predicts a coefficient of variation in consumption for retired people lower than observed, although the difference is not large (3 percentage points). The deterministic nature assumed during retirement may introduce some distortions in the estimation procedure. In particular, as agents do not need to self-insure themselves against future income shocks, they save less and thus hit the liquidity constraint more frequently. The reason behind this assumption comes from the trade-off between estimation precision and dimensionality problems mentioned before. A stochastic retirement problem would force us to numerically solve the value functions during retirement, loosing the closed forms presented in the appendix.

The last rows show the values of two relative frequencies generated by the model. In the benchmark case, the fourth row indicates that about 81 % of the received formal job offers are accepted (and so 19 % of those offers are rejected). Similarly, the fifth row indicates that only 35 % of the informal job offers are accepted, while the remaining 65 % are rejected. These figures reflect the low informality rate observed in Chile (See Gasparini and Tornarolly, 2009) and will be used as benchmark for the counterfactual policy exercises in the next section.

5. Results II: policy-evaluation exercises

As stated in the introduction, structural models are useful to analyze counterfactual policy exercises. This paper considers two alternative reforms for the case of Chile that are especially relevant after the protests observed in 2019.

The first exercise assumes a permanent decrease in the tax rate on formal-wages, from 10 % to 7 %. Although this specific reform is not present in the current policy debate, a cut in the tax rate can be seen as a possible reaction by a Government that is facing the increasing demands against the functioning of the Chilean pension system. Note that the shock is assumed to be permanent. In a general equilibrium framework, this type of reforms must be followed by a reduction in Goverment expenditure in order to insure an intertemporal balanced budget. For the sake of simplicity, we assume that this last reform does not affect the labor market during the life cycle. As time is assumed to be finite, this assumption is mild.

The second policy exercise is a 10 % increase in non-contributory pensions, a frequently discussed type of policy with redistributive goals. This change can be seen as a possible reaction after several suggestions made to the chilean Government.[21] In both cases, the focus is set on labor markets and formality-informality acceptance rates. Table 4 below shows the results of these policy exercises.

The two reforms are equivalent in terms of present value under the parameter structure presented above: the net present value of a 10 % increase in non-contributary pensions equals the 3 % of the mean average in the informal sector. As the Government is assumed to cut taxes by 3 percentage points, the increase in current disposible income equals the present value of the hike in non-contributary pensions. Note however, that in the presence of liquidity constraints and given the possible incertain carrer of any agent in this economy, there are multiple equivalent reforms. For the sake of simplicity, we just calibrate the policy shock for an informal employed worker that will never hit the liquidity constraint.

Panel A of table 4 shows the results regarding the drop in the contribution rate from 10 % to 7 %. The first row shows an increase in the average duration of unemployment. This increase is proportionally quite big (about 23 % from the benchmark case). The mirror image of this increase in the unemployment duration appears in the following two rows: for both types of job offers received by unemployed workers, the frequency of acceptance drops. In the case of formal jobs, the drop in the acceptance rate is about 4 %, while for the informal jobs the drop is much larger, about 32 %.

[21] For example, the recent OECD report on Chile (2018) suggests the increase of the "solidarity pillar" as a strategy to improve inclusiveness for the old in the Social Security system.

Table 4: Results of counterfactual policy excercise

Panel 4.A: Drop in contribution rate from 10 % to 7 %		
This panel reports unemployment duration and the fraction of formal / informal offers accepted. For the last two variables, there are two types of values reported: full model and no retirement.		
Variable	Benchmark	After drop in τ
Average unemployment duration (semesters)	1,769	2,186
Fraction of formal offers accepted (full model)	0,813	0,783
Fraction of informal offers accepted (full model)	0,356	0,243
Fraction of formal offers accepted (no retirement)	0,633	0,795
Fraction of informal offers accepted (no retirement)	0,456	0,278

Panel 4.B: Increase in non-contributory pensions of 10 %		
This panel reports unemployment duration and the fraction of formal / informal offers accepted.		
Variable	Benchmark	After increase in T^{NC}
Average unemployment duration (semesters)	1,769	1,351
Fraction of formal offers accepted (full model)	0,813	0,811
Fraction of informal offers accepted (full model)	0,356	0,369

Source: own computations based on model

Those results can be explained by a dominant mechanism: a drop in the contribution rate decreases the income flow after retirement, afecting the agent in any state. However, the strongest impact of this effect is on formal workers, followed by informal employees and then on the unemployed ones. Thus, the relative value of being unemployed increases (as the value function decresases less than in any other state), making workers more demanding when receiving job offers and consequently risng the duration of unemployement. This mechanism can be seen as a type of *wealth effect*, which counterbalances a more traditional effect, namely, *a substitution effect*. In this effect a decrease in the tax rate generates an increase in the value funcions of the agent in any state as there is a hike in current or (near) future labor income. The impact effect is strongest in formal workers, which explains the mild reaction of acceptance rates in this sector: both susbtitution and wealth effect effset each other. Thus, all the action of the model is in the infomal sector, where the acceptance rate lowers more than the increase in unemployment duration as the formal sector acts as a buffer.

The last two rows of panel A reflect the substitution effect. The table shows the results of a similar exercise on the fraction of formal and informal jobs accepted but modified in an ad-hoc way. This variation consists in dropping all semesters after retirement, keeping only the periods while actively working (or otherwise being unemployed). In this case τ corresponds only to a proper labor income tax rate, not also to a contribution to a retirement fund. Then, a drop in that parameter implies an increase in the propensity of accepting a new formal job and a drop in the propensity to accept an informal one; keeping the duration of unemployment relatively constant (which is not reported for expositional purpose). Moreover, this effect operates not only due to the standard mechanism present in traditional search models with risk-neutral workers, but also reinforced by the effect on asset holdings. That is, the hike in current income is smoothed to the next period, accumulating assets, which in turn increase the reservation wage (and thus rising the unemployment duration) in the near future. In the full model with retirement, those direct effects are more than counterbalanced by the effects on transfers received after retirement. Indeed, the drop in the contribution rate not only implies a decrease in the cost of accepting a new job, but also a reduction in income after retirement. Given the estimated and calibrated values of the parameters, this model shows that *the second effect ends up being stronger than the first one.*

The difference between the two above-mentioned cases suggests that such a change depends crucially on the true planning horizon of workers.[22] Those results indeed suggest that the possible effects of changes in contribution rates are very different (essentially, the opposite) for workers with long-run horizons than for those with short-run horizons. Although the paper does not deal directly with behavioral issues like myopia, this rough exercise presents a first step towards understanding the role of planning horizon when evaluating potential policy reforms in social-security contributions. Besides, to our knowledge at least, such result is novel in the search literature with life-cycle considerations.

[22] This effect is also related to empirical literature linking financial literacy (as in Meier and Sprenger (2013)) and information (as in Fuentes et al (2017)) to voluntary savings for retirement.

The other relevant comment is related to the relationship between the propensity to accept formal / informal jobs. In the case of the full model, the drop in the contribution rate undoubtedly makes the unemployed worker even more reluctant to accept informal jobs than formal ones. This result is in line with the intuition that a drop in such rate makes labor formality less costly for workers. An even sharper result is obtained in the ad-hoc modified model, where the same policy generates a decrease in the number of informal jobs offers which are accepted. Thus, *a drop in contribution rates generates the correct incentives on the labor-supply side, decreasing informality in labor markets, although making unemployment a phenomenon with higher duration.*

The second panel of table 4 evaluates the effects of an increase in non-contributory pensions after retirement. Thus, the mechanism is driven purely by the wealth effect. Unemployment duration drops about 24 % relative to the benchmark value. This drop in fact reflects an increase in the informality rate, measured by the increase in the fraction of new informal jobs by about 3 %. On the other hand, the propensity to accept formal jobs drops very little (less than 1 %). The last result is a bit surprising. Indeed, one would expect a more significant drop in the propensity to accept formal offers when increasing the solidarity pillar. Thus, what is at work here is a mechanism even more extreme to the one at stake in the contribution-rate full exercise, that is, a pure wealth effect. The value functions of the agents raise in all the possible states, but the value of being an informal workers increases the most (the other two move in similar direction and magnitude).

Yet, from both the labor-market informality and the fiscal policies discussion, these results seem undesirable. Indeed, and from a more macro perspective, these results suggest that making non-contributory pension transfers more generous may imply lower incentives to contribute to the formal branch of the social security system and so it may ceteris paribus worsen the fiscal position of the government providing those transfers. However, if the orders of magnitude and the effects on the duration of unemployement are taking into account *an increase in non-contributary pensions are preferred to a cut in the labor tax rate*. In particular, the effects on unemployment duration are similar in magnitude in both policies (changing in a different direction, of course) but the changes in the informality rate are milder in the case of non-contributory pensions.

If we consider the effects on consumption, the above conclusion is reversed. Due to the presence of liquidity constraints, consumption only increases relative to the benchmark in the case of a tax cut. In particular, after a hike in non-contributory pensions, agents choose to increase the acceptance rate in the informal labor market, which has a lower average wage, and can not frontload consumption as much as they want due to the increase in their wealth after retirement. This fact affects significantly the overall impact generated by non-contributory pensions. The table below shows the situation at hand.

Table 6: Summary of simulated results

Effects of a tax cut and a hike in non-contributary pensions.
Deviations with respect to benchmark

Policy	IR (I)	UD (II)	Partial Effect (I+II)	Cons. (III)	Total Effect (I+II+III)
Labor Tax	-(-31)	-(24)	+7	+(+10)	+17
NC Pensions	-(+3.5)	-(-24)	+21	+(-8)	+12.5

-(+XX) implies a negative deviation of XX units with respect to benchmark

Table 6 present an ad-hoc criterion to evaluate the 2 reforms, based on deviations with respect to the benchmark simulations. It is assumed that the policy maker negatively values an increase in the informality rate (IR) and unemployment duration (UD) but positively values a hike in consumption (Cons.). Each of these deviations are equally weigthed. Thus, an increase in non-contributary (NC) pensions is preferred *if the Goverment cares only about the labor market impact of both reforms*, labeled Partial Effect. However, if authorities take into account the overall impact of these measures, their Total Effect, this paper suggests that an increase of disposible income by means of a tax cut is preferred. Note that if policy makers are assumed to be benevolent, we arrive to the same conclusion as househlods only value consumption (i.e. the instantaneous utilitily function only depends on it). Thus, we provide evidence in favor of the relevance of financial frictions for the desing of labor market reforms as they explain why taxes normatively dominates transfers.

6. Conclusions

This paper has presented a labor-search model with life-cycle elements, with the major goal of quantifying counterfactual policy experiments. There are two major directions for future research. The first one is of methodological order. Introducing life-cycle elements into search models always represents a challenge for estimation through SMM methods. The main challenge comes from the well-known curse-of-dimensionality issues, which in these models seem severe since the life-cycle elements introduce an additional dimension of heterogeneity. Undoubtedly this should constitute a focal point for future research to develop methods that allow improving the precision, extending the scope of the estimation (i.e., extending the number of parameters to be properly estimated) and also the possibility of estimating parameters with richer assumptions (e.g., dropping the assumption of deterministic lives after retirement, as assumed in this paper).

The second direction is related with the evaluation of economic policies and the use of these models to address it. The asymmetric results on formal job acceptance observed in table 4 between the benchmark case and the model with agents not taking into account the retirement years represent a first step towards a more systematic line of research regarding the relevance of the planning horizons to the desing of labor markets and social-security reforms. This is also particularly relevant when dealing with labor informality issues as can be seen in the response of consumption to future lump-sum transfers.

Other venues for future research include for example the introduction of the labor-demand side. In this regard, it is clear that the random-matching models with bargaining (such as those by Bosch and Esteban-Pretel 2012 and 2015) must be the starting point to introduce life-cycle issues. Yet, to our knowledge such extension has not been tried yet, possibly due to computational complexities, among others.

Other extensions include adapting search models with explicit intra-household analysis. Indeed, Adda et al (2017) and Haan and Prowse (2017) constitute recent contributions of models analyzing marriage, fertility and labor-search considerations that is explicitly estimated through simulation-based methods. No attempt to extend such analysis to Emerging Market countries is known at this time. Such extensions may imply richer and more subtle effects that a model without such considerations may generate.

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Appendix

Estimation and computation of the model

This appendix provides a rough description of the method used to compute and estimate the probabilities of being fired when employed and of finding a new job offer when unemployed. As suggested in other papers such as Low et al (2010), a major challenge to the computation of the model presented in this paper is the effect of employment decisions and savings choices on the efficiency of the algorithm. Moreover, this difficulty is worsened by the endogeneity of reservation wages and the non-stationarity of the dynamic programming program. These problems forced us to limit the number of parameters estimated using simulation methods.

The algorithm is based on five codes[23], each of which is allocated in a separate file. The first file is called "SLC". This file contains the active part of the life cycle. Agents take labor and saving decisions. Agents accumulate savings and make employment decisions according to equations (6), (8) and (9) in the main text. The second file is called "retNS". This file contains the consumption and saving decisions of the retired agents. As explained above, retired agents receive two types of transfers: contributive, associated with compulsory savings, and non-contributive transfers from the government. These decisions are made according to equation (3) in the main text. The third file is "CFNS" (NS means non-segmented labor market) puts together active and non-active decisions and compute the level of assets for the period previous to retirement (the last active period). This is done in equation (10). The file "EST" computes the "matched" parameters (δ,α) according to the observed values for the coefficient of variation of consumption and average duration of unemployment. Finally, the file "markovchain" simulates a finite state space Markov process.

The estimation procedure runs as follows. The first step is to run the EST file providing as an input the vector of the three moments used for estimation, using the syntactic expression ESTNS(0.15, 0.43, 1.5). As explained in the main text, the first and second inputs are the coefficient of variation of consumption for the active life and retired life respectively. The last number is the average duration of unemployment. The process for wages is in fact assumed to be iid (all rows of the transition matrix are equal). The values for the wages (formal and informal sector) are taken from the data as well as the probability associated with each possible value.

The EST file provides as output a first iteration for the estimated parameters, using the simulated method of moments, named as "alphastarNS" and "lambdastarNS" in the code. We repeat the procedure several times and compute the average across simulations. That is, the name "alphastarNSj" is the output of the j-th execution of the code "ESTNS". The reported valued must be an average of across the J simulations. These averages are the estimated calling (alphastarNS_Avg) and lay-off probability (lambdastarNS_Avg).

The algorithm uses these average values "alphastarNS_Avg" and "lambdastarNS_Avg" to run the file "CFNS". This file provides a series of consumption, assets, and labor-decision statistics listed as an output of the code. The next step repeats the procedure several times and average the values across simulations for each time (i.e. $CANS_{i,t}$ is the consumption (C) of the agent during her active (A) life in a non-segmented (NS) labor market, in period "t", simulation "i". ($\frac{\sum_i CANS_{i,t}}{I}$) must be the reported value, where "I" is the number of simulations).

The files "CFNS", "retNS", "CFNS", "ESTNS" and "markovchain" are available under request.

Finally, in order to compute the model, we had to make an additional assumption. As suggested by Pakes and Pollard (1989), the backward induction nature of lyfe cycle models coulpled with the dependence of equation (10) on the expost value of savings Y_{T-1} make the problem intractable as the guess value for Y_{T-1} may not be realized ex-post after any possible simulation.

Thus, we assume that the last period of active life depends only on a_T, the asset level selected in period $T-1$, and not on the value of the program in the month before retirement, V^e_{T-1} in equation (10). That is, the value function for the last period of active life, $T-1$, *relevant for the period before that* is different

[23] All codes are written in MATLAB® language.

with respecto to the value function used to compute optimal decisions *for the period inmmediately after* $T-1$. The former is equal simply to:

$$V^e_{T-1}\left(Ra_{T-1}+y^e_{T-1};Y_{T-1}\right)=\text{máx}_{a_T}\ \frac{\left(Ra_{T-1}+y^e_{T-1}-a_T\right)^{1-\sigma}}{1-\sigma}$$

The latter is equation (10). This assumption implies that our simulations underestimate the effect of retirement wealth on labor markets. However, the level of assets a_T is increasing in the value of the program in the first period of retirement as it is computed using equation (10). We solve the active part of the life cycle using a given value for a_T and then compute a_T as a solution of equation (10). This strategy implies that we have a different value for, say, unemployment duration for each possible level of assets in the grid and then we select the one associated with the maximal level of a_T according to equation (10).

Closed forms for the retired agents

Before-the-Last period

This is the period characterized as age $T+\mathcal{T}$ and month 11. Set-up problem:

$$\max_{a_{T+T,12}}\frac{\left(Ra_{T+\mathcal{T},11}+\tau_{T+\mathcal{T},11}-a_{T+\mathcal{T},12}\right)^{1-\sigma}}{1-\sigma}+\beta\frac{\left(Ra_{T+\mathcal{T},12}+\tau_{T+\mathcal{T},11}\right)^{1-\sigma}}{1-\sigma}\tag{1}$$

FOC

$$\left(Ra_{T+\mathcal{T},11}+\tau_{T+\mathcal{T},11}-a_{T+\mathcal{T},12}\right)^{-\sigma}=\beta R\left(Ra_{T+\mathcal{T},12}+\tau_{T+\mathcal{T},12}\right)^{-\sigma}\tag{2}$$

or

$$\left(Ra_{T+T,12}+\tau_{T+T,12}\right)=\left(\beta R\right)^{\frac{1}{\sigma}}\left(Ra_{T+\mathcal{T},11}+\tau_{T+\mathcal{T},11}-a_{T+\mathcal{T},12}\right)\tag{3}$$

so

$$a_{T+\mathcal{T},12}(*)=\frac{\left(\beta R\right)^{\frac{1}{\sigma}}\left(Ra_{T+\mathcal{T},11}+\tau_{T+\mathcal{T},11}\right)-\tau_{T+\mathcal{T},12}}{R+\left(\beta R\right)^{\frac{1}{\sigma}}}$$

$$c_{T+\mathcal{T},11}(*)=\frac{R\left(Ra_{T+T,11}+\tau_{T+T,11}\right)+\tau_{T+\mathcal{T},12}}{R+\left(\beta R\right)^{\frac{1}{\sigma}}}$$

$$c_{T+\mathcal{T},12}(*)=\frac{\left(\beta R\right)^{\frac{1}{\sigma}}\left[R\left(Ra_{T+\mathcal{T},11}+\tau_{T+\mathcal{T},11}\right)+\tau_{T+\mathcal{T},12}\right]}{R+\left(\beta R\right)^{\frac{1}{\sigma}}}$$

so

$$U_{T+\mathcal{T},11}=\left[R\left(Ra_{T+T,11}+\tau_{T+T,11}\right)+\tau_{T+T,12}\right]^{1-\sigma}\frac{\left[1+\beta(\beta R)^{\frac{1-\sigma}{\sigma}}\right]}{\left[R+\left(\beta R\right)^{\frac{1}{\sigma}}\right]^{1-\sigma}}$$

Two months before death

The savings problem is given by:

$$\text{máx}_{a_{T+T,11}}\ \frac{\left(Ra_{T+T,10}+\tau_{T+\mathcal{T},10}-a_{T+T,11}\right)^{1-\sigma}}{1-\sigma}+\beta\frac{\left[1+\beta(\beta R)^{\frac{1-\sigma}{\sigma}}\right]\left[R\left(Ra_{T+\mathcal{T},11}+\tau_{T+T,11}\right)+\tau_{T+T,12}\right]^{1-\sigma}}{\left[R+\left(\beta R\right)^{\frac{1}{\sigma}}\right]^{1-\sigma}}$$

The FOC is

$$
\begin{aligned}
&\left(Ra_{T+T,10}+\tau_{T+\mathcal{T},10}-a_{T+\mathcal{T},11}\right)^{-\sigma} \\
=&\beta R^{2}\frac{\left[1+\beta(\beta R)^{\frac{1-\sigma}{\sigma}}\right]\left[R\left(Ra_{T+\mathcal{T},11}+\tau_{T+\mathcal{T},11}\right)+\tau_{T+\mathcal{T},12}\right]^{-\sigma}}{\left[R+(\beta R)^{\frac{1}{\sigma}}\right]^{1-\sigma}}
\end{aligned}
$$

Equivalently this expression, after some algebra, becomes:

$$
\begin{aligned}
&\left[R\left(Ra_{T+\mathcal{T},11}+\tau_{T+\mathcal{T},11}\right)+\tau_{T+\mathcal{T},12}\right] \\
=&\beta^{\frac{1}{\sigma}}R^{\frac{2}{\sigma}}\frac{\left[1+\beta(\beta R)^{\frac{1-\sigma}{\sigma}}\right]^{\frac{1}{\sigma}}}{\left[R+(\beta R)^{\frac{1}{\sigma}}\right]^{\frac{1-\sigma}{\sigma}}}\left(Ra_{T+\mathcal{T},10}+\tau_{T+\mathcal{T},10}-a_{T+\mathcal{T},11}\right)
\end{aligned}
$$

Which in turn implies:

$$
a_{T+\mathcal{T},11}(*)=\frac{\beta^{\frac{1}{\sigma}R^{\frac{2}{\sigma}}}\left[1+\beta(\beta R)^{\frac{1-\sigma}{\sigma}}\right]^{\frac{1}{\sigma}}\left[\left[R+(\beta R)^{\frac{1}{\sigma}}\right]^{\frac{1-\sigma}{\sigma}}\right]^{-1}\left(Ra_{T+\mathcal{T},10}+\tau_{T+\mathcal{T},10}\right)-\left(R\tau_{T+\mathcal{T},11}+\tau_{T+\mathcal{T},12}\right)}{R^{2}+\left[\beta^{\frac{1}{\sigma}R^{\frac{2}{\sigma}}\left[1+\beta(\beta R)^{\frac{1-\sigma}{\sigma}}\right]^{\frac{1}{\sigma}}}\right]\left[R+(\beta R)^{\frac{1}{\sigma}}\right]^{\frac{-(1-\sigma)}{\sigma}}}
$$

$$
c_{T+\mathcal{T},10}(*)=\frac{R^{2}\left(Ra_{T+T,10}+\tau_{T+T,10}\right)+\left(R\tau_{T+T,11}+\tau_{T+T,12}\right)}{R^{2}+\left[\beta^{\frac{1}{\sigma}R^{\frac{2}{\sigma}}\left[1+\beta(\beta R)^{\frac{1-\sigma}{\sigma}}\right]^{\frac{1}{\sigma}}}\right]\left[R+(\beta R)^{\frac{1}{\sigma}}\right]^{\frac{-(1-\sigma)}{\sigma}}}
$$

$$
c_{T+\mathcal{T},11}(*)=\frac{\beta^{\frac{1}{\sigma}R^{\frac{2}{\sigma}}}\left[1+\beta(\beta R)^{\frac{1-\sigma}{\sigma}}\right]^{\frac{1}{\sigma}}\left[\left[R+(\beta R)^{\frac{1}{\sigma}}\right]^{\frac{1-\sigma}{\sigma}}\right]^{-1}\left[R^{2}\left(Ra_{T+\mathcal{T},10}+\tau_{T+\mathcal{T},10}\right)+\left(R\tau_{T+\mathcal{T},11}+\tau_{T+\mathcal{T},12}\right)\right]}{R^{2}+\left[\beta^{\frac{1}{\sigma}R^{\frac{2}{\sigma}}\left[1+\beta(\beta R)^{\frac{1-\sigma}{\sigma}}\right]^{\frac{1}{\sigma}}}\right]\left[R+(\beta R)^{\frac{1}{\sigma}}\right]^{\frac{-(1-\sigma)}{\sigma}}}
$$

Consequently the value function for the retired agent three months before she dies becomes:

$$
U_{T+\mathcal{T},10}=\frac{\left[R^{2}\left(Ra_{T+T,10}+\tau_{T+T,10}\right)+\left(R\tau_{T+T,11}+\tau_{T+T,12}\right)\right]^{1-\sigma}}{\left[R^{2}+\left[\beta^{\frac{1}{2}R^{\frac{2}{\delta}}}\left[1+\beta(\beta R)^{\frac{1-\sigma}{\sigma}}\right]^{\frac{1}{\sigma}}\right]\left[R+(\beta R)^{\frac{1}{\sigma}}\right]^{\frac{-(1-\sigma)}{\sigma}}\right]^{\frac{1-\sigma}{\sigma}}}\left[1+\beta\frac{\beta^{\frac{1-\sigma}{\sigma}}R^{\frac{2(1-\sigma)}{\sigma}}\left[1+\beta(\beta R)^{\frac{1-e}{\sigma}}\right]^{\frac{1-\sigma}{\sigma}}}{\left[R+(\beta R)^{\frac{1}{\sigma}}\right]^{\frac{1-\sigma^{2}}{\sigma}}}\right]
$$

Time of retirement(induction)

By induction, then by the first month of retirement the value is

$$U_{T,1} = \frac{[R^{12\mathcal{T}} a_{\mathcal{T}} + \sum_{s=1}^{12\mathcal{T}} R^{12\mathcal{T}-s} \tau_s]^{1-\sigma}}{1-\sigma} \Phi_{T,1}(\beta, R)$$

with

$$\Phi_{T,1}(\beta, R) \equiv \frac{[1 + (\beta R^{(12\mathcal{T}-1)(1-\sigma)})^{\frac{1}{\sigma}} \Phi_{T,2}(\beta, R)]}{[R^{12\mathcal{T}-1} + (\beta R^{(12\mathcal{T}-2)})^{\frac{1}{\sigma}} \Phi_{T,2}(\beta, R)]^{1-\sigma}}$$

More in general, for any year t such that $T \leq t \leq T + \mathcal{T}$ then

$$\Phi_{t,m}(\beta, R) \equiv \frac{[1 + (\beta R^{(12\mathcal{T}-(12-m)t)(1-\sigma)})^{\frac{1}{\sigma}} \Phi_{t,m+1}(\beta, R)]}{[R^{(12\mathcal{T}-(12-m)t)} + (\beta R^{(12\mathcal{T}-(12-m+1)t)})^{\frac{1}{\sigma}} \Phi_{t,m+1}(\beta, R)]^{1-\sigma}}$$

Where the last difference equation is modulo 12 and where

$$\Phi_{T+\mathcal{T},12}(\beta, R) = \frac{1 + \beta(\beta R)^{\frac{1-\sigma}{\sigma}}}{[R + (\beta R)^{\frac{1}{\sigma}}]^{1-\sigma}}$$