Pension design with a large informal labor market: Evidence from Chile

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This draft: July 3, 2012

Abstract

The effects of pension programs on labor supply and savings depend on the nature of informal labor markets ("residual"?, "competitive"?), with large fiscal implications. Linked administrative and self-reported panel data from Chile are used to estimate a dynamic household labor supply and saving decision model with a formal and an informal sector. Parameter estimates suggest that: lack of access to formal jobs accounts for only 14% of informal work; avoidance of mandatory pension contributions is limited; minimum pension benefits can reduce female pension coverage significantly regardless of their design but different designs have very different fiscal costs.

JEL Classification: J240, J260, E210, E260, O170

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†I thank Petra Todd, Ken Wolpin, Dirk Krueger, Olivia Mitchell and the participants at the Penn Macro Club and the Empirical Micro Lunch for their helpful comments. I gratefully acknowledge financial support from the TRIO (PARC/Boettner/NICHD) Pilot Project Competition and from the Center for Retirement Research at Boston College. Formerly circulated under the title "Dynamic labor supply and saving incentives in privatized pension systems: evidence from Chile"

1 Introduction

The existence of a sizeable informal labor market, in which participation in government programs is difficult to mandate, poses formidable challenges for designing pension systems. Over the last three decades, many countries have introduced or considered introducing privately managed individual accounts-based programs with strong ties between contributions and pensions.[1] In Chile, the earliest and most influential example of such a reform, proponents of an individual accounts system hoped that it would lead to smaller distortions, thus increasing participation in the pension system.[2] Instead, 27 years later, with much of its workforce lacking pension coverage, Chile shifted gears by dramatically expanding the role of the state as a provider of retirement benefits.

If workers can easily move between formal and informal sectors, both contributory and non-contributory pensions can create incentives to avoid the formal labor market, with large fiscal implications as pointed out by Piggot et al. (2009).[3] This paper explores the impact of different pension system designs, within a dynamic model of household savings and labor supply in a dual labor market, estimated on Chilean data. The estimated model has the following implications. Labor market segmentation (i.e. the existence of barriers to entry in the formal sector) is found to be small and limited to workers with next to no schooling. Despite this relative absence of restriction to intersectoral mobility, mandatory pension contributions have limited crowd-out effects on pension

[1] Chile (1980), Peru (1993), Argentina (1994), Mexico (1997), Hungary (1998), Poland (1999), Bulgaria (2000) are examples of actual reforms, but such programs have been envisaged in many other countries, in particular in the United States in 2005.

[2] See Corsetti and Schmidt-Hebbel (1997)

[3] Contributory pensions are benefits strongly tied to the pension contributions accumulated over the work life, while non-contributory pensions are usually means-tested minimum pensions provided by the state.

system coverage and on savings. In contrast, minimum pension benefits can reduce female pension coverage significantly as they implicitly tax pension contributions. However, attempts to improve incentives through tapered benefits, which decrease slowly with the level of the contributory pensions, only result in a higher fiscal cost.

A priori, the effects of pension system rules on pension coverage and the fiscal cost of old age benefits should be in large part determined by the propensity of workers to respond to incentives by switching between formal jobs, in which they contribute to the pension system, and informal jobs or self-employment. The importance of this margin depends crucially on whether there are barriers to entry into the formal labor market. A long tradition in labor and development economics has posited that work in the formal sector is rationed. Though differences in estimated earning equations in the two sectors were initially taken as a validation of the segmentation hypothesis, it was later argued that comparative advantages and compensating wage differentials could lead to distinct wage equations without rationing.[4] More recent papers, following descriptive work by Maloney (1999), have examined panel aspects of the data such as sector transitions (Gong et al. (2004)) and wage differentials (Gong and Van Soest (2002)) using dynamic multinomial logit models with random effects. My approach uses both sector transitions and wage differentials to identify the extent of segmentation within a dynamic structural framework to derive its implications for policy.[5] The model builds on the dynamic occupational choice model of Keane and Wolpin (1997), interpreting the formal and informal sectors as

[4]Dickens and Lang (1985), Heckman and Hotz (1986), Magnac (1991), Gindling (1991)

[5]In a calibrated equilibrium search and matching framework, Albrecht et al. (2009) explore the effects of payroll and severance taxes on unemployment duration, the distribution of skills in the formal and informal sectors and welfare

occupations, and allowing for pension and non-pension savings accumulation and labor market segmentation.

In the model, workers can always work in the uncovered sector, but they might have to queue for jobs in the covered sector. In addition, incentives to work in the covered sector are dynamically affected by labor supply decisions made in previous periods as both spouses endogenously accumulate sector-specific human capital. The other dynamic structural models that incorporate an informal labor market to study pension design do not allow for segmentation, rather assuming a priori that workers can move freely between sectors (Valdés-Prieto (2008), Velez-Grajales (2009)).[6]

My model has two other important features that interact with pension system rules and sector choice. The first is a saving decision, which generates an implicit choice of portfolio between a taxable, relatively liquid asset and a tax-deferred, illiquid asset (pension savings). How that tradeoff evolves over the life cycle as a function of the relative strength of the precautionary and retirement saving motive has been studied in the context of individual retirement accounts (IRAs).[7] More recently, Dammon et al. (2004) and Gomes et al. (2005) look at the optimal life cycle portfolio choice between taxable and tax-deferred accounts and evaluate the welfare cost from contributing at a suboptimal rate. Importantly, the level of accumulated private and pension savings also influences labor sector choice by changing the value of additional

[6]An exception is Robalino et al. (2008), who specify and estimate a dynamic stochastic model in which agents can save privately and exert effort to increase their probability of working in the formal sector, to estimate the potential effect of a large set of social insurance policies in the context of Brasil. They estimate preference parameters using age profiles of the fraction of individuals in the covered, uncovered, unemployed and retired states, but do not use data on wages, assets, sector-specific experience or longitudinal transitions.

[7]Gale and Scholz (1994), Engen et al. (1994), Engen et al. (1996), Hubbard et al. (1995))

illiquid pension contributions. The second important feature of my model is the joint labor supply decision made by the spouses. Van der Klaauw and Wolpin (2008) highlight the importance of allowing for income risk pooling within the household to accurately study the incentives created by social pension programs.[8] In the context of pension design, for example, spouses may choose to work in different sectors to qualify for a minimum pension while at the same time avoiding oversaving. Having one spouse work in the informal sector can alleviate the reduction of disposable income resulting from mandatory pension contributions.

The parameters of the earnings offer function, of preferences and of the probability of receiving a covered job offer are estimated using the simulated method of moments.[9] A unique data set collected for the purpose of analyzing social protection in Chile and the pension system in particular is used; the data are composed of a longitudinal survey ("Encuesta de Proteccion Social", or EPS) linked with administrative data from the pension system's regulatory agency. The survey data include retrospective employment histories, as well as self-reported household labor earnings and household assets collected in 2002, 2004 and 2006. The administrative data contain the longitudinal history of pension savings of the respondents since the 1980 pension reform.

Using the estimated model, several possible minimum pension designs are simulated. To anchor the analysis, I consider variations around the design chosen in the actual 2008 reform implemented in Chile. The objectives of the reform were to protect workers with few pension contributions against poverty

[8] Other recent examples include Gustman and Steinmeier (2000), Gustman and Steinmeier (2002), Blau and Gilleskie (2006).

[9] See McFadden (1989)

in old age while improving incentives to pay pension contributions. The model includes the two channels by which retirement transfers can affect pension coverage. First, benefits can reduce labor force participation through an income effect. Second, an implicit tax exists if additional pension contributions render the worker ineligible for, or reduce his claims to, retirement benefits. I find that women's labor force participation is much more responsive than men's as minimum pension benefits are made more generous. In addition, the implicit tax effect is very small compared to the income effect. As a result, highly tapered minimum pension benefits do not improve incentives significantly despite being much costlier.

The estimated model is also used to quantify the importance of the disincentives associated with mandatory pension contributions. How many workers choose to work informally to avoid paying contributions? Are workers likely to offset pension savings by reducing their private savings? Regarding the first question, increases in the mandatory contribution rate can affect pension coverage and labor force participation by reducing the value of covered earnings offers, as a larger fraction of the income becomes illiquid. However, in counterfactual simulations with different contribution rates, this effect is found to be relatively small: a one percentage point increase reduces participation in the covered sector by slightly less a percentage point. Regarding the second question, crowd out effects of private savings by pension savings are also moderate. Only a quarter of the mandatory increase in pension savings is offset by a reduction in private savings as households need non-pension savings to smooth consumption during working years.

The paper is structured as follows. Section 2 provides background information on the Chilean pension system. Section 3 lays out the structural model. Section 4 describes the data, estimation procedure, parameter estimates and model fit. Section 5 shows results from the policy experiments. Section 6 concludes.

2 Background: The Chilean Pension System

This section describes the aspects of the current system modeled in the paper. The current Chilean pension system, known as the "AFP" (Administradoras de Fondos de Pensiones, or Pension Funds Administrators) system was created on November 4, 1980.[10] The main component of the new AFP pension system is a savings program based on defined-contribution individual accounts. The program is mandatory for salaried workers and voluntary for the self-employed. Affiliated workers must pay 10% of their monthly wages in a tax-deferred pension account that is locked until retirement.[11]

The worker can choose from a number of pension fund administrators (the

[10]Before 1980, Chile had a heterogeneous social security system composed of up to 32 different "Cajas de Prevision" that covered different professions and categories of the population. The reform was motivated by a vicious circle of chronic deficits financed by the state that represented 40% of payments in 1980, skyrocketing contribution rates (over 50% of a worker's monthly remuneration in 1974), and increasing payment evasion (the ratio of active contributors over people in work fell from 83 in 1973 to 71 in 1980), which accentuated the decline in the contributors-to-pensioners ratio (3.5 in 1973, 2.2 in 1980). A unified institution named Institute of Social Security Normalization (INP) now manages pensioners and workers who did not choose to join the AFP system.

[11]The contributions are capped at 60 UFs. UFs, or Unidades de Fomento, are indexed on inflation; a UF was 17,317 pesos (US$31) as of December 2004. In addition to the 10% pension contribution, workers must pay a contribution of 7% for health services, 0.8% for a disability and survivorship insurance, and 2.6% to the pension fund manager as a commission or fee.

AFPs) who manage the savings deposited in the account and invest them in the financial markets.[12] Initially, AFPs were required to invest all of the funds in government bonds, but they have gradually been allowed to offer a broader array of investment choices, including foreign assets and stocks.[13]

Workers can access their pension savings at 65 years old for men and 60 years old for women. They have three withdrawal options: programmed withdrawals (retiro programado), purchase an annuity from an insurance company (renta vitalicia), or a mix of phased withdrawals for a period of time and a deferred lifetime annuity.[14]

Before 2008, the state provided retirement income transfers through two mechanisms. A welfare or assistance pension (*pension asistencial*, or PASIS), equal to about 1/3 of the minimum wage, was provided to individuals above 65 years of age, irrespective of their contribution history, provided that their earnings and their household's per capita earnings were both below that level.[15] The second transfer was a minimum pension guarantee (MPG) equal to about twice the PASIS: individuals with more than 20 years of contribution would receive the MPG if their accumulated contributions could not finance a higher

[12]The number of AFPs has changed over the years, reaching 32 in 1997 but was down to 5 in 2008. The risk-return options offered by the different AFPs are very close so the model does not incorporate a choice of administrator.

[13]In addition, since 2002, each AFP must offer 5 portfolio options, called multifunds, to their affiliates. The funds are labeled A to E with an increasing weight on fixed-income assets. By default, older workers are assigned to a more conservative portfolio (D or E). As a simplification, the model assumes that all pension funds follow the same iid process, estimated on the returns of fund C, by far the largest.

[14]The law allows for early retirement, provided that the worker can obtain a pension equal to or greater than 110% of the minimum pension guaranteed by the state. The pension must also be equal to or greater than 50% of the average taxable income for the last 10 working years

[15]In 2007, the PASIS was 44.186 per month for workers between 65 and 70, 47.103 between 70 and 75, and 51.503 between 75 and 80 (US$82, US$87 and US$95 per month, respectively).

pension. Both these benefits took the form of a top-up: the benefit was equal to the difference between the guaranteed level and the pension financed by the worker's account.

In the late 2000s, the analysis of histories of pension contributions at the micro level revealed that about half of the working population was contributing too little to the system to finance a minimum pension or to qualify for the state MPG. This led in 2008 to an overhaul of the system of minimum pensions paid by the state.[16] The 2008 reform replaced the PASIS and MPG with a unified "new solidarity pillar" composed of a means-tested welfare pension that guarantees to all individuals in the 60% less affluent fraction of the population a pension of 75,000 pesos per month.[17] This represents an increase of nearly 50% with respect to the PASIS. The main innovation is that instead of constituting a floor pension, the benefits are gradually reduced, at a rate of 30%, for workers with some accumulated pension contributions.[18] The new system ensures that an additional contribution always increases the level of the retirement pension, and it maintains a constant implicit marginal tax rate of about 37% on additional contributions.

[16]The reform also tackled other problems such as insufficient price competition in the AFP industry or gender equity, but I focus on the reform of the eligibility and level of the safety net.

[17]The current level is 60,000 pesos but will be increased gradually until 2012.

[18]That is, a worker who can finance a pension of 100,000 pesos per month with the funds accumulated in her individual account will receive a benefit equal to 75,000 - (100,000*0.3)=45,000. Her total pension will then be 145,000 pesos per month.

3 The Model

The model represents the decision problem of a married or unmarried couple.[19] The optimization problem starts when the couple is formed ($t = t_0$). Initial conditions are composed of work experiences and schooling levels of both spouses and the household's assets. A period corresponds to a calendar year and is indexed by the husband's age. Spouses are assumed to remain together until they both die at $t = t_D$.

To keep the model tractable, I assume that both spouses claim their pension benefits and stop working at $t = t_R$. At each working age $t \in \{t_0, ...t_R - 1\}$, households make two decisions: the household consumption decision c_t and a joint labor force participation decision $d_t = (d_t^H, d_t^W)$, where H, W refers to Husband and Wife. Three employment options are available to spouse $j \in \{H, W\}$: to work in the covered sector ($d_t^j = 1$), to work in the uncovered sector ($d_t^j = 2$), or to stay home ($d_t^j = 3$). After retirement, both spouses stay at home ($d_t = (3, 3)$) and only make a consumption decision.

Couples form a unitary household with a single common period utility function. They care about total household consumption through a CRRA utility function. They also care about whether each spouse works or not through non-pecuniary benefits derived from leisure denoted by δ^H and δ^W. Finally, they pay a cost when switching between covered and uncovered sectors (ϕ_s^H, ϕ_s^W), and when returning to work after a period at home (ϕ_a^H,ϕ_a^W). For all

[19] I use the husband/wife terminology in both cases for simplicity.

$t \in \{t_0, t_D\}$, the period utility function is given by:

$$\begin{aligned} u(c_t, d_t) &= \frac{c_t^{1-\sigma}}{1-\sigma} + (\delta^H + \epsilon_t^H) \cdot I_{\{d_t^H=3\}} + (\delta^W + \epsilon_t^W) \cdot I_{\{d_t^W=3\}} \\ &+ \phi_s^H \cdot (I_{\{d_t^H=1, d_{t-1}^H=2\}} + I_{\{d_t^H=2, d_{t-1}^H=1\}}) + \phi_a^H \cdot I_{\{d_t^H \neq 3, d_{t-1}^H=3\}} \\ &+ \phi_s^W \cdot (I_{\{d_t^W=1, d_{t-1}^W=2\}} + I_{\{d_t^W=2, d_{t-1}^W=1\}}) + \phi_a^W \cdot I_{\{d_t^W \neq 3, d_{t-1}^W=3\}} \end{aligned}$$

where the shocks to the value of leisure are assumed to be distributed normally and to be uncorrelated over time: $(\epsilon_t^H, \epsilon_t^W) \sim iidN(0, \Sigma_p)$.

The model's state variables are the following: a_t denotes the household's non-retirement or private savings at age t; B_t^H and B_t^W are the balances on the retirement accounts of the two spouses at age t; $X_{U,t}^H$, $X_{U,t}^W$, $X_{C,t}^H$ and $X_{C,t}^W$ are the four stocks of sector-specific experience, with the subscripts U and C denoting the uncovered and covered labor sectors. They correspond to the number of years each spouse has worked in each sector up to period t. E^H and E^W are the schooling levels of the spouses. d_{t-1} is the pair of labor decisions in the previous period. c is the birth cohort of the husband.

Lifetime preferences are additively separable over time and can be expressed for all $\tau \in \{t_0, t_D\}$ as a function of the state variables:

$$V_\tau(\Omega_t) = \sum_{t=\tau}^{t_D} \quad u(c_t(\Omega_t), d_t(\Omega_t))$$

where $\Omega_t = \{a_t, B_t^H, B_t^W, E^H, E^W, X_{C,t}^H, X_{U,t}^H, X_{C,t}^W, X_{U,t}^W, d_{t-1}; c\}$, $i \in \{H, W\}$ is the spouse-specific subscript, $j \in \{U, C\}$ is the sector-specific subscript.

Households face a two-sector labor market with a covered and an uncovered sector. Each spouse may receive a stochastic earnings offer from the covered

sector that depends on her level of schooling and sector-specific experience stocks as well as the birth cohort of the husband. Each spouse also receives a stochastic earnings offer from the uncovered sector with probability 1. The probability Γ_t^i for spouse i to receive an earnings offer from the covered sector in period t captures the possibility that there is excess supply of labor in the covered sector, so that workers must queue for jobs and might not be allowed to work at the market wage. Γ_t^i is a logistic function of education, the number of years of covered experience, and having been employed in the covered sector in the previous period:

$$\Gamma_t^i = (1 + exp\{-(\gamma^i + \gamma_{cov}^i I_{\{d_{t-1}^i=1\}} + \gamma_E^i E^i + \gamma_{XP}^i X_C^i)\})^{-1}$$

The log-earnings offers (for spouse $i \in \{H, W\}$, in sector $j \in \{C, U\}$) are given by

$$w_{j,t}^i = \alpha_j^i + \theta_c^j \cdot c + \theta_{E,j}^i \cdot E^i + \theta_{X,j}^i(E) \cdot (X_j^i + \tau_{XP}^j X_{-j}^i) + \epsilon_{j,t}^i$$

where α_j^i is a gender- and sector-specific constant, θ_c^i a sector-specific cohort effect, $\theta_{E,j}$ the returns to schooling, $\theta_{X,j}^i(E)$ are the returns to experience, and $\tau_{XP}^j \in [0, 1]$ captures the transferability of cross-sector experience. $\epsilon_{j,t}^i$ is an iid sector-specific earnings offer shock that is uncorrelated across time periods and potentially correlated within a household: $(\epsilon_{j,t}^i)_{j=U,C}^{i=H,W} \sim N(0, \Sigma_o)$. The total household disposable labor income y_t is the sum of accepted earnings offers, net of contributions: $y_t = \sum_{i \in \{H,W\}} ((1-\tau) \cdot w_{C,t}^i \cdot I_{\{d_t^i=1\}} + w_{U,t}^i \cdot I_{\{d_t^i=2\}})$, where τ is the pension contribution rate.

Covered labor earnings net of pension contributions and private savings returns are subject to a progressive income tax. Taxes due at period t are denoted $T(a_t, w^H_{C,t}, w^W_{C,t}, d_t)$, and depend on the household's stock of private savings, received covered sector offers and decisions to accept them. Net borrowing and borrowing against pension savings is not allowed. Private savings earn the risk-free rate r. The balances on each spouse's pension account accrue interest stochastically and are augmented by the current period's contribution. Returns on the pension accounts are modeled as an iid process: $r_B \sim iidN(\bar{r_B}, \sigma^2_B)$.[20]

The optimization problem faced by the household at working ages can be written recursively:

$$\begin{aligned} V_t(\Omega_t) &= \max_{c_t, d_t}\{u(c_t, d_t) + \beta E V_{t+1}(\Omega_{t+1})\}, \quad s.t. \\ a_{t+1} &= y_t + a_t \cdot (1+r) - c_t - T(a_t, w^H_{C,t}, w^W_{C,t}, d_t), \quad a_{t+1} \geq 0 \\ B^i_{t+1} &= B^i_t \cdot (1 + r_B) + \tau \cdot w^i_{C,t} \cdot d^i_{C,t}, \ i \in \{H, W\} \end{aligned}$$

At retirement, spouses stop working: $d_t = (3,3)\ for\ t > t_R$. They receive as a lump sum the welfare or minmum pension benefits if they meet the eligibility criteria and then withdraw all pension savings and pool them with their private savings: $a_{t_R} := a_{t_R} + B^H_{t_R} + B^W_{t_R} + Benefits$. There is no uncertainty remaining at this point, and households run down their total accumulated private and pension savings by optimally saving and consuming until they die. Letting a_t denote the total amount of savings at t, pensions included, the problem of the

[20] Allowing for serial correlation in the returns would require adding past returns as additional continuous state variables, which would significantly complicate the numerical solution of the problem

retired household becomes:

$$\begin{aligned} \forall t \in \{t_R, ...t_D\},\ V_t(a_t) &= \max_{a_{t+1}} \{u(c_t, (3,3)) + \beta \cdot EV_{t+1}(a_{t+1})\} \\ where \quad c_t &= a_{t+1} - a_t \cdot (1+r), \quad a_t \geq 0 \\ and \quad V_{t_D+1}(a_{t_D+1}) &= 0 \end{aligned}$$

which can easily be solved analytically.[21] For working periods, the model does not have an analytic solution. Instead, a numerical solution procedure approximates the expected value function at all possible realizations of the state space by backward recursion (See Keane and Wolpin (1994) for further details).[22]

[21]The solution is derived from the period budget constraints, the terminal condition $a_{t_D+1} = 0$ and the set of Euler equations, which upon iteration yield, for each $t \in \{t_R, ...t_D - 1\}$, $c_t = c_{t_R} \cdot (\beta(1+r))^{\frac{t-t_R}{\sigma}}$. A vertical summation of the period budget constraints, premultiplied by $(\frac{1}{1+r})^{t-t_R}$, yields: $a_{t_R} = \sum_{t=t_R}^{t_D} (\frac{1}{1+r})^{t-t_R} c_t$. The solution is characterized by consumption at each period as a function of assets at retirement:

$$\begin{aligned} c_{t_R} &= a_{t_R} \cdot \frac{1}{\sum_{t=t_R}^{t_D} (\frac{p_t}{p_{t_R}} \cdot (\beta(1+r)^{1-\sigma})^{t-t_R})^{\frac{1}{\sigma}}} \\ \forall t \in \{t_R, ...t_D - 1\} \quad c_t &= c_{t_R} \cdot (\beta(1+r))^{\frac{t-t_R}{\sigma}} \end{aligned}$$

[22]In our case, given the continuation value function ("$Emax(t)$"), optimal consumption is obtained for each value of the deterministic and shock components of the state space by comparing utility on a grid of possible consumption levels, for each of the nine possible choices of husbands' and wives' labor sectors. At the corresponding deterministic state point, the expected value of V_{t-1} is obtained by Monte Carlo integration over the shock realizations. This calculation is effectuated at a subset of the possible deterministic state points and the function is approximated outside of the subset by a regression on functions of the state variables.

4 Data and Estimation

The model is estimated using individual and household earnings, labor sector choice and asset data from the *Encuesta de Proteccion Social* longitudinal survey (EPS) together with the linked administrative records of pension balances and contributions to retirement accounts, obtained from the Chilean supervising agency for pensions (*Superintendencia de Pensiones* (SP)).[23]

The 2006 survey contains information on a representative sample of 16,443 individuals age 15 or older. For the 14,337 of them that are affiliated with the AFP pension system, the administrative records of all the transactions on their pension accounts are linked to the EPS survey.

The variables used in the estimation are age, schooling level, schooling level of the spouse, number of years the respondent worked in the covered sector, number of years the respondent worked in the uncovered sector, labor sector choice, labor sector choice of the spouse, annual accepted earnings, individual pension wealth and private household wealth. Details on the construction of the variables are provided in appendix A.

The estimation sample includes 2097 individuals who were born between 1965 and 1981. The sample used in the estimation is restricted as follows. First, I keep 8193 married and cohabiting couples that have been together at least from 2002 to 2006. Of those, I exclude 822 who kept their affiliation with the old pension system, which is not modeled in this paper. Couples formed after

[23]EPS is a new household survey, conducted in 2002 by the Microdata Center (Centro de Microdatos) of the Department of Economics of the Universidad de Chile. It was initially called HLLS (Historia Laboral y Seguridad Social) and later renamed EPS (Encuesta de Proteccion Social). The questionnaire was designed specifically to study Chile's social protection public programs. In 2004 and 2006, two follow-up surveys were administered. The 2009 follow-up survey was administered in the course of 2009 and was not used in this study.

the husband turned 25 were also dropped to avoid having households with significant asset accumulation and work experience prior to marriage, since initial conditions are kept fixed in the policy experiments. This leaves 4154 couples. The final sample consists of the 2097 households that were formed after 1980 and were subject only to the post-1980 privatized pension system. The oldest cohorts are observed from the age of 25 to the age of 51, while the youngest cohorts are observed only one or two years (see Table 1).

Table 2 presents summary statistics for the sample. Median private savings at age 35 in the sample are about 4.8 million pesos, or about $\$8,000$. This corresponds roughly to twice the median earnings in the covered sector. In comparison, median pension savings at the same age are about 2.3 million pesos for males and 0.3 million pesos for females. The relative importance of pension savings increases over the life cycle.[24]

The median male worker earns 2.4 million pesos annually when working in the covered sector versus 1.7 million pesos in the uncovered sector. This difference is in part due to the different levels of schooling in the two sectors. The sample is divided into 4 schooling levels: No High School, High School Dropouts, High School Graduates and College Graduates. Lower schooling levels are over-represented in the uncovered sector: the fraction of males with no high school education is 24% among uncovered workers versus 15% in the total sample. Table 2 also reports the joint sector choices made by households in the sample: about 37% of households have two working members, 59% have one, and 4% have none. Among two-income households, a third are split with each spouse in a different sector.

[24]The fact that the median female pension savings is much lower and is decreasing with age is due to low female labor force participation, particularly for older cohorts.

The fraction of working years spent in the covered sector reveals three types of workers. Twenty percent of males and 25% of females work less than 25% of the time in the covered sector. That is, they almost only work in uncovered jobs. Similarly, 60% of males and 58% of females work almost exclusively in covered jobs. Finally, a large fraction of the sample (20% of males and 17% of females) switches in and out of covered jobs.

Estimation method

I estimate the model using the Method of Simulated Moments (MSM).[25] I use the approximated age-dependent value functions, conditional on the state variables, to simulate moments of the wealth, sector-specific earning and labor choice distributions. The moments are generated for any given set of parameters by simulating the behavior of 5 "clones" of the $2,097$ couples in the estimation sample. The estimation procedure then minimizes the distance between the simulated moments and corresponding data moments. The weights are the inverses of the estimated variances of the moments. The total number of moments is $M = 953$; the number of parameters to be estimated is $K = 59$. The moments of the joint distribution of savings, sector and labor force participation choices used for the estimation are listed in appendix B.

The model starts when the couple is formed. The pension savings and experience are available for the respondent to the survey but not for his or her spouse. Each spouse is matched to a survey respondent conditional on gender, schooling, and schooling of the spouse and assigned that respondent's

[25]This method more easily accommodates missing state variables than does simulated maximum likelihood, which would require integrating over possible values of missing state variables.

values of pension savings and experience. In addition, wealth measures are only available only in 2004 and 2006. The missing initial household savings are drawn from the wealth levels of new couples observed in those two years. Unobserved heterogeneity is introduced through three discrete types that affect the value of leisure of both spouses. The probability of being a certain type follows a logit and is allowed to depend on the schooling levels of the husband and the wife and on the birth cohort of the husband. The model is solved for all three types, and simulated households draw a type before the first period according to the logit model.

Table 3 reports the estimated proportions of the three types in the population and summary statistics for each type. Sixty-five percent of the sample is type 2. About one-third is type 1. These are older, less educated couples, for whom coverage and female labor force participation are lower. Type 3 couples constitute a very small minority, 2% of the sample. These are older and atypical couples in which the husband tends to be less educated than the wife. For type 3 couples coverage is low but female labor force participation is high.

Model Fit

A challenge of this study is to account jointly for the savings, earnings, labor force participation, and sector choice dimensions of the data, which is essential to study pension policy design.

First, as seen in table 4, the model reproduces the bimodal distribution of time spent in the covered sector at different ages and for the two genders. For example, 18.8% of men under 35 have worked less than 25% of the time in covered jobs (18.8% in the data), while 58.7% have worked more than 75%

of the time in covered jobs (58.5% in the data). Table 5 shows the individual transition matrices for 45 to 50-year-old men and women and for their younger counterparts (25-30). In particular, the persistence in sector choices is adequately captured for both genders and age groups.

Second, the joint labor force participation of couples in the nine possible pairs of employment choices (table 6) is also well captured. So are the individual choices of husbands and wives, summarized by age and schooling level (table 7). For example, the model reproduces the high percentage of women with no high school education who stay home (14.8% versus 13.4% in the data) and the much lower percentage for college graduates (27.4% versus 25.0% in the data).

Third, the model is able to generate the overall dispersion of the private savings, pension savings and earnings in the sample, as seen in tables 8 and 9. In addition, the education and age patterns of mean savings and earnings are well captured overall. Two aspects of the fit could be improved. First, the model tends to under-predict pension savings accumulation at older ages for college graduates. Looking at earnings, the mean for that schooling level is also lower in the model simulations than in the data. In fact, the earnings of college graduate exhibit a fat right tail of high earners that the model is not well equipped to capture. The fact that these high earnings are persistent over time explains that this right tail in the earnings distribution also translates into a fat right tail in the pension savings distribution, which is responsible for the underestimation of college graduates' pension savings. The pension savings accumulated by these high earning individuals will tend to pull the mean up at older ages.[26] The second aspect is the low mean earnings of younger males

[26]A possible remedy would be to introduce unobserved heterogeneity in the earnings offer, effectively allowing for persistently high earnings and pension savings accumulation for a

and of females in the uncovered sector. This comes from workers who are only partially employed during the year, a situation that is common in the uncovered sector at younger ages. Since I make the simplifying assumption not to model the intensive margin of the labor supply decision, the model is not well equipped to capture that fact.

5 Results

Parameters Estimates

Tables 10, 11, 12 and 13 report parameter estimates with the standard errors in parentheses. The discount rate is estimated at 0.067 (for a discount factor of 0.937). This is slightly higher than what is usually found in models estimated or calibrated on American data (usually under 0.05). However, the ratio $\frac{1+r}{1+\rho}$, which drives asset accumulation, is close to what is found elsewhere in the literature at 1.013.[27] The elasticity of intertemporal substitution is estimated at 1.559, which is within the (wide) range of estimates found in the literature.[28]

Experience transferability is estimated to be high, at 0.97.[29] This indicates that sector-specific human capital accumulation is not an important factor in keeping workers away from the covered sector. It is consistent with the fact that covered and uncovered jobs are not restricted to different occupations

fraction of the sample.

[27] compared to 1.011 in Gourinchas and Parker (2002), for example.

[28] For example, with a comparable model, Van der Klaauw and Wolpin (2008) find estimates of 1.59 and 1.68, and Gourinchas and Parker (2002) obtain an estimate of 1.397.

[29] That is, returns to one year of cross-sector experience are equal to 97% of returns to one year of same-sector experience.

and activities, as illustrated in table 14.[30] Also, the returns to education are estimated to be higher in the uncovered sector than in the covered sector (3.4% higher for men and 1.8% higher for women). This implies that the earnings gap between sectors is higher for low schooling levels, which is consistent with the fact that queueing is also more likely for these workers as described in the next section.

Extent of Labor Market Segmentation

The probability of receiving a covered offer captures the extent of labor market segmentation faced by workers with different schooling and experience levels. The estimated coefficients of the logistic model for schooling, experience in the covered sector, and being in the covered sector in the previous period are positive as expected. Thus, a more educated worker, or one who has worked many years in the covered sector (particularly if it is in the previous year), is less likely to have to queue for covered jobs. This translates into predicted probabilities at all levels of the covariates are between 0.95 and 0.99, which indicates a low level of labor market segmentation overall. To see this, the working decisions of each couple are counterfactually simulated under the assumption that all workers receive a covered and an uncovered sector offer in every period. As seen in table 15, the size of the uncovered sector under this "no-segmentation" counterfactual, is reduced by 14% overall but the reduction is much larger for workers with no high school education (22%) than for college graduates (7%). These numbers can be interpreted as the fraction of uncovered work that is explained by segmentation.

[30]It must be noted that the standard errors on this parameter are relatively high at 0.111.

Pension contributions avoidance

The estimated model can also be used to quantify the importance of the disincentives associated with the illiquidity of contributions. How many workers choose to work informally in order to avoid paying contributions? Table 16 reports coverage rates under counterfactual contribution rates ranging from 5% to 20%.[31]

The exercise essentially measures the elasticity of pension coverage to the level of pension contributions implied by the model. Increases in the mandatory contribution rate can affect pension coverage and labor force participation by reducing the value of covered earnings offers, as a larger fraction of the earnings become illiquid. Table 16 shows that households significantly adjust their labor force participation in response to a change in mandatory savings. Increasing the contribution rate from 10 to 15% decreases the coverage rate by 3.7 percentage points, or 5.9%, for husbands and 4.3 percentage points, or 16.5%, for wives.[32]

The coverage rate by itself provides an incomplete picture of participation in the pension system. It does not capture whether the same workers participate continuously over their lifetime while others never do or whether most workers switch in and out of covered jobs to some extent. Table 17 shows the distribution of contribution densities at age 64 (age 59 for women) under

[31]For these projections, realized pension returns after 2009 are assumed to be 5.98%, which corresponds to the weighted average return on Chile's pension funds from 2002 to 2009.

[32]In extrapolating from these elasticities, one must take into account that the contribution rate affects eligibility for the minimum pension guaranty. At low contribution rates, it is much easier to accumulate 20 years of contributions while remaining under the minimum pension threshold, which is apparent in the last two lines of table 16. This illustrates that while the existence of mandatory pension contributions is usually rationalized as a way to help myopic individuals plan for retirement, they are also a way to keep the cost of safety net programs low.

a contribution rate of 10% and 15%.[33] As expected, contribution densities are lower when the contribution rate is higher. However, different parts of the distribution are affected by changes in the contribution rate for men and women. Women who reduce their participation in the covered sector are those with low contribution densities.[34] In contrast, the whole contribution density distribution for males shifts to the left.

Do mandatory pension contributions crowd-out other savings?

The contribution rate is sometimes viewed as a policy tool to increase aggregate savings by effectively imposing a lower bound on a household's overall saving rate. However, the magnitude of that effect depends on the extent to which households can make countervailing adjustments to their private savings. The simulated average private, pension and total savings for the sample in 2004 under the different contribution rates are reported in table 18. The results show that total savings respond strongly to an increase in the contribution rate: increasing the contribution rate from 10 to 15% increases average total savings by 13.4%, from 10.8 to 12.2 million pesos. [35] Because households require non-pension savings to smooth consumption during working years, the crowding-out of non-pension savings by pension savings is relatively limited.

[33]Contribution densities are defined as the number of years in which contributions were made over the number of working-age years. I define working ages as ranging between 16 and 64 for men (59 for women).

[34]In other words, a higher contribution rate discourages sporadic participation in the covered sector.

[35]This effect can be decomposed into an increase in pension savings (+1.7 million pesos for males and +0.3 million pesos for females), partially offset by a decrease in private savings (-0.6 million pesos).

6 Safety Net Design

The following policy experiments explore possible designs for the safety net program, including the one chosen for the 2008 reform described in section 2. The objectives of the reform were to protect workers with few pension contributions against poverty in old age while improving incentives to pay pension contributions. The model includes the two channels by which retirement transfers can affect pension coverage. First, benefits can reduce labor force participation through an income effect. Second, the safety net might create an implicit marginal tax on additional pension contributions if they render the worker ineligible for, or reduce his claims to, retirement benefits.

The designs considered in the policy experiment are illustrated in figure 1.[36] The scenarios differ by the taper rate applied to the benefits, which graphically translates into the steepness of the corresponding benefit line. The top-up design, represented by a horizontal line, means that the benefit is reduced by 1 peso for each peso that a worker can self-finance with her accumulated pension savings. Thus, the top-up design generates a 100% implicit marginal tax rate on pension contributions for workers who expect to be eligible for the safety net benefits. In contrast, a universal pension, in which the benefit level is independent of the self-financed or contributory pension, generates no implicit marginal tax. On the graph, that design corresponds to the benefit line that runs parallel to the contributory pension line. Two intermediate cases are considered: the actual 2008 reform, which implemented a 30% taper rate, and a "high taper rate case," in which the taper rate is twice that of the 2008

[36]To make alternative designs comparable, I keep the same intercept, which corresponds to the benefit received by a worker with no accumulated pension savings.

reform, i.e., 60%.

I consider the question of whether each design improves or reduces pension coverage and compare their costs to the government as well as the effect on fiscal revenue due to changes in participation in the covered sector.[37] This exercise requires making an assumption on the realized rate of return achieved by pension funds. In the simulations, I use the mean return from 2002 to 2009 of 5.98%.[38]

Given that they are primitives of the model, the estimated preference parameters can be taken as invariant to policy changes. The prices in the labor and capital markets, however, might be subject to equilibrium adjustments when pension rules are changed.[39]

[37] I simulate the sample's lifetime decisions under each scenario until 2039, which is when every worker has spent his or her entire work life under the 1981 pension system. To obtain a representative cross-section in 2039, conditional on sample restrictions, I draw initial conditions for new couples formed after 2006 using those of the youngest cohort of couples in the sample and simulate their lifetime decisions as well. That way I can do a meaningful comparison of tax revenues collected, and pension benefits paid, by the government under the different scenarios. Note that the experiments are not tax-neutral: the additional cost to the government is not translated into higher taxes. Results for same policy changes modeled as an unanticipated and tax-neutral event will be the subject of future work.

[38] Before 2000, each pension fund managed a unique portfolio. I use the average of all the funds' returns weighted by their value at the end of each year. In 2000 and 2002, pension funds were required to manage additional portfolios with different risk-return profiles. By default most accounts were consigned to the medium risk portfolio or "fondo C," whose returns I use in calculating returns post-2000.

[39] Equilibrium effects could operate through three channels. First, asset returns might adjust to an increase or a reduction in household savings, thus attenuating the behavioral response to the policy change. It seems reasonable to assume, however, that Chile is a small open economy and that asset returns are invariant to the policy experiment. Second, the adjustment in the relative wages of the covered and uncovered sector can be expected to reduce the extent to which workers switch sectors in response to changes in the rules of the system. Similarly, if new rules cause workers to reduce their labor force participation, wages might go up in equilibrium and limit the magnitude of the response. The wage equilibrium effects are outside the scope of my paper, so the estimates of the employment responses to the policy experiments presented here should be taken as upper bounds on the equilibrium response.

Findings

The effects of different safety net designs on sector choice and labor force participation at different ages are reported in tables 19 and 20. Men's decisions show no discernible effect either in terms of coverage or in terms of labor force participation. Labor force participation near retirement, in particular, remains largely unaffected, which implies that the different designs would have little impact on retirement age. In particular, the more generous design implemented with the 2008 reform does not appear to create incentives to retire early for men.

This is not so for women who exhibit sizeable responses to the different designs. The strongest effects concern labor force participation (see table 20) toward the end of the work life and the main difference is shown between the baseline system and the other four. Labor force participation drops by about 1 percentage point at early ages, up to 8 percentage points in the decade preceding the legal retirement age. By contrast, the differences between the four non-baseline designs do not exceed 1.5 percentage points,[40] reflecting the fact that under the baseline system the amounts of the transfers are overall much smaller than in the other four scenarios. In other words, the wealth

[40]Though they are small, the differences between the last four designs are interesting. The lowest labor force participation and coverage rates are to be found under the universal pension design. This seems at odds with the fact that universal pensions create the least amount of distortion or implicit marginal taxes. However, the universal pension design is the least targeted of the four, which implies that the wealth effect will impact the largest fraction of the population (in fact it should affect everybody to some extent). This trade-off between the wealth effect and implicit marginal taxes explains that the coverage and labor force participation rates are not always monotonic in the taper rate. For example, women's labor force participation at ages 50-60 is highest for the high taper rate design (which has a 60% taper rate), and the coverage rate for the same age group is highest at the 30% taper rate chosen for the actual 2008 reform. At earlier ages, the wealth effect dominates the implicit marginal tax effect even more, so the top-up system is the one that maximizes the fraction of women working and covered.

effect associated with the level of benefits dwarfs the implicit marginal tax effects created by the different taper rates.[41]

Ultimately, the trade-off between the different designs is a fiscal one. A first look at table 21 shows that the more generous benefits implemented by the 2008 reform come at an important fiscal cost. In fact the new system is predicted to be twice as costly. The next question is whether the taper rate chosen was the optimal one.[42] A priori, low taper rates were expected to create fewer distortions and to improve coverage and labor force participation, thereby improving fiscal revenue, which would compensate for their higher cost. Table 21 shows that quantitatively the two sides of the equation do not compare. While tax revenue varies by less than 6% across safety net designs, pension benefit outlays change dramatically from one to the other. Not surprisingly, the outlays decrease with the taper rate, so that the top-up system is the most economical of the alternative designs. In other words, if the objective is to provide a minimum level of income in retirement, the cheapest way to do so is with a simple, top-up minimum pension, at a small cost in terms of coverage, labor force participation and fiscal revenue.

[41] The fact that the effects become stronger with age likely reflects the gradual resolution of uncertainty regarding income and asset return risk. At earlier ages, the likelihood of becoming eligible for safety net benefits, as well as the amount of wealth available for consumption, is still not precisely known, which dampens the behavioral responses.

[42] I do not conduct a tax-neutral welfare analysis here; my main goal is merely to provide an order of magnitude for possible crowd-out effects relative to the benefit outlays.

7 Conclusion

The existence of a large uncovered labor market, in which it is difficult to mandate participation in pension schemes, poses formidable challenges for designing pension systems in developing countries. In many of them, the fraction of workers who contribute to the existing pension scheme is low. In this context, choosing how much workers should contribute could affect participation, pension savings accumulation and ultimately the cost to the state to provide a safety net in the form of retirement income subsidies. Conversely, generous eligibility requirements and benefits for such a safety net could also crowd out individual pension and private savings, further increasing the fiscal cost of the system. This study explores these mechanisms by specifying and estimating a dynamic model of employment and savings decisions for a sample of Chilean couples under a privatized pension system. The model explicitly incorporates the main features of the pioneering Chilean pension system and allows households to adjust to pension regulation through a private saving decision and by varying the labor force participation decision of each spouse. In addition, the model accounts for the existence of a large uncovered labor market, in which household members can work without being subject to pension contributions. In particular, this study attempts to determine to what extent pension rules themselves can be held responsible for the problem of low participation in the pension system. Specifically, are workers avoiding pension contributions? Do social pensions crowd out contributions? Or are workers being rationed out of covered jobs due to labor market segmentation? In addition, it tries to assess what the effects of actual or potential policies that aim to increase income in retirement will be. This includes increasing the contribution rate and expanding

social pensions in the way Chile did in 2008.

I find that Chilean data used in estimation are broadly consistent with a competitive, as opposed to a segmented, uncovered labor market sector. Labor market segmentation accounts for only 14% of uncovered work overall (up to 22% for workers with no high school education).

Participation in jobs covered by the pension system is found to be sensitive to the rules of the pension system. A higher contribution rate reduces participation in jobs that are covered by the pension system at a rate of 1 percentage point of coverage per additional percentage point of contribution. Private and pension savings are found to be only partial substitutes. Higher contributions would be partially offset by a reduction in private savings: the decrease in private savings equals roughly 25% of the increase in pension savings. This implies that increasing contributions from 10% to 15% would increase total savings by 14%.

The model is used to compare different safety net designs, including an actual reform implemented in 2008 in Chile. I find that sizeable effects on labor force participation and coverage are limited to women toward the end of their work life (up to 8 percentage points near retirement), and that they depend on the generosity of the safety net pensions rather than the specific design chosen. As a result, the gains from reducing distortions by using low taper rate designs appear very limited relative to the large increases in outlays involved. To put it differently, if the objective of the safety net is to provide a minimum level of income in retirement, the cheapest way to do so is with a simple, top-up minimum pension, at a small cost in terms of coverage, labor force participation and fiscal revenue.

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A Variable construction

The schooling level variables were constructed as a discrete indicator taking values 4 (individuals with less than 8 years of schooling), 8 (individuals with 8 to 11 years of schooling), 12 (individuals with 12 to 15 years of schooling), and 16 (individuals with 16 years of schooling or more). The four categories are labeled No High School, High School Dropout, High School Graduate and College Graduate for simplicity hereafter.

Respondents were asked to report their spells of employment since their first job or since 1980, whichever happened last. Employment spells in salary jobs with a contract were coded as covered, while self-employed spells and salary jobs without a contract were classified as uncovered.[43] From employment spells, a monthly indicator of employment status was constructed. This monthly indicator was aggregated to an annual indicator in the following way. A respondent with no working months during the year is Home($d_t^3 = 1$). A respondent with a majority of months in covered jobs is Covered ($d_t^2 = 1$), and a respondent with a majority of uncovered jobs is Uncovered ($d_t^2 = 1$). The annual indicator was then summed from the year in which the respondent turned 16 over each successive year to obtain the number of years in each labor choice. Regarding the spouse's labor sector choice, it was constructed in the same way for the years the survey was administered (2002-2004-2006). Monthly labor earnings were reported for each employment spell starting in 2002. They were summed over each year to obtain annual accepted earning.

[43]For self-employed workers, contributions to the system are optional rather than mandatory. About one out of six self-employed workers is actually covered (Arenas de Mesa et al. (2004)). This paper assesses the effect of the constraint imposed by mandatory savings on coverage, so that self-employed workers, who are not subject to that constraint, are classified as uncovered.

Household wealth was reported in the 2004 and 2006 surveys and is composed of main housing, real estate, cars, savings, equipment, businesses and debts. The pension wealth of the EPS respondent was obtained from the pension account administrative records in the following way. Every time a pension contribution is made (i.e., every month worked in a covered job), the transaction records the balance of the account at the time of the contribution. For months in which the respondent didn't work in a covered job (i.e., was at home or working in an uncovered job), the balance is computed using the last available balance, the returns obtained by the corresponding pension fund, and the commissions or fees charged by the pension fund manager. All variables except for pension balances are available for both spouses in years 2004 and 2006. Pension balances are available for the survey's interviewee from 1980 to 2005 but not for his or her spouse. Labor decisions of the survey's interviewee are reported from 1980 to 2006 and his or her earnings from 2002 to 2006.

B List of moments used in estimation

Joint Labor Sector Choice:
% households choosing each of the nine joint occupations by age group
% households choosing each of the nine joint occupations by schooling level of the husband
% households choosing each of the nine joint occupations by schooling level of the wife
% two-income households by age group
% two-income households by schooling level of the husband
% two-income households by schooling level of the wife
% one-income households by age group
% one-income households by schooling level of the husband
% one-income households by schooling level of the wife
% husbands choosing each of the three alternatives by schooling level
% husbands choosing each of the three alternatives by age group
% wives choosing each of the three alternatives by schooling level
% wives choosing each of the three alternatives by age group
% husbands choosing each of the three alternatives by 5-year tranches of covered experience
% husbands choosing each of the three alternatives by 5-year tranches of uncovered experience
% wives choosing each of the three alternatives by 5-year tranches of covered experience
% wives choosing each of the three alternatives by 5-year tranches of uncovered experience
% husbands choosing each of the three alternatives by age group and birth cohort
% wives choosing each of the three alternatives by age group and birth cohort

Earnings:
The mean annual log-earnings by sex, age and sector
The variance of the annual log-earnings by sex, age and sector
The mean annual log-earnings by sex, age and schooling level
The variance of the annual log-earnings by sex, age and schooling level
The mean annual log-earnings by sex, sector and experience
The mean first-difference in annual log-earnings by current and 1-year lagged sector and by sex
The mean first difference in annual log-earnings by age, current sector and by sex

Wealth:
The mean private savings level by age and schooling level of the husband
The mean private savings level by age and schooling level of the wife
The variance of private savings by age
The variance of private savings by schooling level of the husband
The variance of private savings by schooling level of the wife
The mean pension savings level by sex, age and schooling level
The variance of pension savings by sex and age
The variance of pension savings by sex and schooling level
% with no private savings by age group
% with private savings between 0 and 6 million pesos by age group
% with private savings over 6 million pesos by age group
The mean private savings level by age and current sector of the husband
The mean private savings level by age and current sector of the wife
The mean pension savings level by age group and birth cohort

Career Transitions:
2-period joint transitions of number of working spouses in the household
1-period transitions between the three employment statuses by age group and sex
Mean years in each sector by age group and sex
% of years in covered sector under age 35 by sex
% of years in covered sector over age 35 by sex
% of years at home under age 35 by sex
% of years at home over age 35 by sex

C Tables and Figures

Figure 1: The 2008 reform of the Chilean pension safety net and alternative designs.

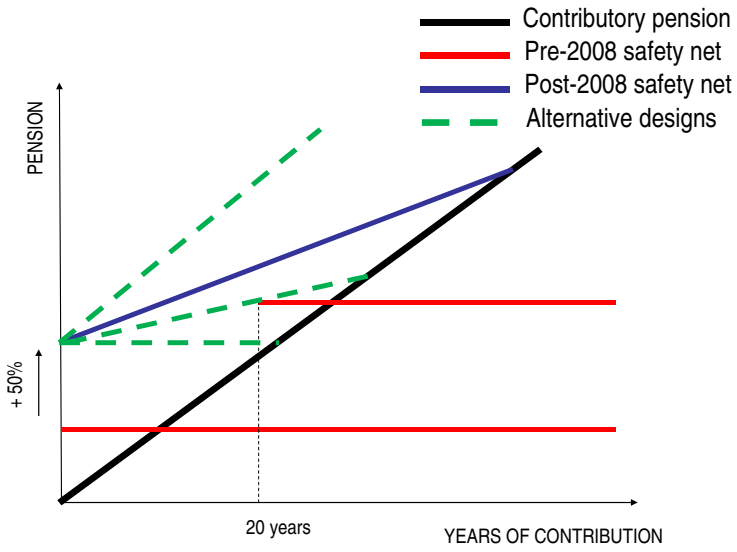

Table 1: Person-period observations by age group and birth cohort

	Age of the Husband						
Birth cohort	25	30	35	40	45	50	**Total**
1955	2,775	2,776	2,780	2,780	2,460	321	13,892
1965	3,282	3,280	3,280	2,888	411	0	13,141
1970	2,840	2,840	2,499	355	0	0	8,534
1975	2,402	2,160	307	0	0	0	4,869
1980	1,621	250	0	0	0	0	1,871
Total	12,920	11,306	8,866	6,023	2,871	321	42,307

Table 2: Summary statistics

	Husband	Wife	Household
Private assets (million pesos)			
median at 25	-	-	1.5
median at 35	-	-	4.8
median at 45	-	-	8
Pension savings (million pesos)			
median at 25	0.3	0.1	-
median at 35	2.3	0.3	-
median at 45	4.5	0.0	-
Median annual earnings (million pesos)			
Covered sector jobs	2.4	1.5	-
Uncovered sector jobs	1.7	0.7	-
Years worked in covered jobs			
>75% of total number of years	60%	58%	-
<25% of total number of years	20%	25%	-
Schooling level (sample)			
No High school	15%	15%	-
High school dropouts	36%	36%	-
High school graduates	43%	45%	-
College graduates	6%	4%	-
Schooling level (Uncovered sector workers)			
No High school	24%	14%	-
High school dropouts	42%	40%	-
High school graduates	31%	42%	-
College graduates	2%	5%	-
Joint labor sector choice			
Husband's/Wife's sector			
Covered/Covered	-	-	18%
Covered/Uncovered	-	-	8%
Covered/Home	-	-	40%
Uncovered/Covered	-	-	6%
Uncovered/Uncovered	-	-	5%
Uncovered/Home	-	-	17%
Home/Covered	-	-	1%
Home/Uncovered	-	-	1%
Home/Home	-	-	4%

Table 3: Unobserved types

Type	**1**	**2**	**3**
% of sample	32.8	65.4	1.8
Age	39.1	36.6	43.2
% of Men with no High School	25.6	5.9	50.5
% of Men with College Degree	1.7	8.9	0.0
% of Women with no High School	23.7	8.0	6.0
% of Women with College Degree	1.6	6.6	9.8
% of Women Working	18.4	54.1	64.1
% of Men in Covered Job	69.8	79.1	41.3
% of Women in Covered Job	11.3	40.8	36.4

Table 4: Model fit: distribution of fraction of years worked in covered jobs

	(%) Husbands (age < 35)		(%) Wives (age< 35)		(%) Husbands (age> 35)		(%) Wives (age> 35)	
	Data	Model	Data	Model	Data	Model	Data	Model
0-25%	18.8	18.8	24.1	32.1	12.7	15.9	15.2	22.5
25-50%	8.1	6.2	8.8	7.9	7.3	6.8	6.8	5.4
50-75%	14.3	16.6	9.2	12.8	13.4	15.4	10.9	8.6
75-99%	23.0	29.7	10.1	10.5	17.5	20.9	11.0	8.0
100%	35.7	28.8	47.8	36.7	49.1	41.0	56.1	55.5

Table 5: Model fit: Transitions between labor sector choices

		Husbands (age 25-30)		Wives(age 25-30)		Husbands (age 45-50)		Wives (age 45-50)	
		Data	Model	Data	Model	Data	Model	Data	Model
% from C	to C	95.5	91.5	84.2	94.5	93.5	94.2	83.7	90.8
	to U	3.7	7.4	2.5	0.7	5.4	4.9	9.3	0.8
	to H	0.8	1.1	13.3	4.8	1.1	0.9	7.0	8.5
% from H	to C	31.5	31.8	4.2	3.2	27.3	18.2	3.9	0.8
	to U	6.6	23.1	2.4	3.7	13.6	16.7	8.7	3.2
	to I	61.9	45.0	93.4	93.1	59.1	65.2	87.4	95.9
% from U	to C	9.6	21.2	5.6	3.0	12.9	11.5	5.6	2.2
	to U	89.8	76.4	79.2	78.9	83.0	81.7	78.7	78.8
	to H	0.5	2.4	15.2	18.1	4.1	6.8	15.7	19.0

C: Covered, U: Uncovered, H: Home

Table 6: Model Fit: household labor force participation

	Data (%)	Model (%)
Husband's/Wife's sector		
Covered/Covered	18.0	20.0
Covered/Uncovered	7.5	8.6
Covered/Home	40.2	41.7
Uncovered/Covered	6.3	8.6
Uncovered/Uncovered	4.9	3.6
Uncovered/Home	16.7	14.5
Home/Covered	1.4	2.0
Home/Uncovered	0.9	0.3
Home/Home	4.1	0.5

Table 7: Model fit: labor sector choice by age and schooling

	Husbands		Wives			Husbands		Wives	
	Data	Model	Data	Model		Data	Model	Data	Model
Fraction in the covered Sector									
Age					**Schooling**				
20	66.0	63.9	30.8	23.9	No H.S.	51.4	63.7	13.4	14.8
30	68.3	70.2	26.1	27.0	H.S. dropout	63.4	66.8	19.3	18.5
40	60.7	69.7	24.4	23.9	H.S. grad	75.2	71.2	34.3	31.6
					Col. Grad	77.6	76.4	61.5	64.9
Fraction in the uncovered Sector									
Age					**Schooling**				
20	26.2	31.4	10.4	8.7	No H.S.	42.0	27.6	10.7	8.5
30	28.4	26.2	11.2	12.4	H.S. dropout	32.8	29.5	14.4	11.3
40	33.8	26.4	18.0	10.1	H.S. grad	21.0	26.8	11.7	12.3
					Col. Grad	14.8	23.1	13.5	7.8
Fraction in the home sector									
Age					**Schooling**				
20	7.8	4.7	58.8	67.3	No H.S.	6.6	8.7	75.9	76.7
30	3.3	3.6	62.8	60.6	H.S. dropout	3.8	3.7	66.3	70.2
40	5.5	3.9	57.6	66.1	H.S. grad	3.8	2.0	54.0	56.1
					Col. Grad	7.6	0.5	25.0	27.4

Table 8: Model Fit: savings

	Private savings		Husband's pension savings		Wife's pension savings	
	Data[a]	Model[a]	Data[a]	Model[a]	Data[a]	Model[a]
mean	6.46	7.35	1.21	1.22	.29	.28
sd	8.41	7.80	2.22	1.72	.90	.87
p10	-.06	.09	0	0	0	0
p50	4.12	5.45	.39	.58	0	0
p90	16.25	16.54	3.20	3.35	0.75	0.78
By Age						
20	3.64	4.03	.18	.29	.07	.10
30	5.46	6.94	1.50	1.58	.34	.35
40	8.09	8.39	4.91	3.80	1.15	.85
By Education						
No HS	4.75	4.98	.50	.57	.07	.23
HS dropout	5.51	6.75	.91	1.03	.16	.26
HS grad	7.04	7.84	1.59	1.48	.42	.32
College grad	11.86	11.81	2.75	2.29	.56	.38

[a]In million pesos (1 USD = 475 Chilean pesos as of 9/12/2011)

Table 9: Model Fit: earnings

	Husbands				**Wives**			
	Covered Sector		**Uncovered Sector**		**Covered Sector**		**Uncovered Sector**	
	Data[a]	Model[a]	Data[a]	Model[a]	Data[a]	Model[a]	Data[a]	Model[a]
Distribution								
mean	2.92	2.97	2.41	2.63	1.78	1.68	1.13	0.86
sd	2.13	1.99	2.13	2.00	1.21	1.35	1.03	0.62
p10	1.38	1.20	0.72	0.81	0.41	0.54	0.15	0.31
p50	2.4	2.50	1.80	2.14	1.56	1.33	0.84	0.70
p90	5.35	5.26	4.71	5.04	3.60	3.23	2.40	1.58
By Age								
20	2.08	2.41	1.57	2.44	1.40	1.06	0.77	0.72
30	2.96	2.82	2.54	2.59	2.01	1.57	0.96	0.80
40	3.21	3.31	2.39	2.67	1.62	2.09	1.21	0.98
By Schooling level								
No HS	1.77	1.57	1.42	1.11	0.93	0.87	0.72	0.44
HS dropout	2.18	2.32	2.13	2.00	1.23	1.18	0.96	0.73
HS grad	3.29	3.35	3.09	3.34	1.92	1.77	1.32	0.95
College grad	6.44	5.96	5.50	5.35	2.89	2.82	2.31	1.77

[a]In million pesos (1 USD = 475 Chilean pesos as of 9/12/2011)

Table 10: Parameter estimates: preferences

Name	Symbol	Value[a]
Discount rate	ρ	0.067 *(0.002)*
Intertemporal Elasticity of Substitution	σ	1.559 *(0.037)*
Value of leisure (Female - type 1)	δ^W	0.085 *(0.003)*
Value of leisure (Female - type 2)	δ^W	0.044 *(0.002)*
Value of leisure (Female - type 3)	δ^W	0.180 *(0.017)*
Value of leisure (Male - type 1)	δ^H	0.095 *(0.007)*
Value of leisure (Male - type 2)	δ^H	0.009 *(0.002)*
Value of leisure (Male - type 3)	δ^H	0.008 *(0.019)*
Cost of switching sectors (Male)	ϕ_s^H	0.074 *(0.004)*
Cost of switching sectors (Female)	ϕ_s^W	0.262 *(0.017)*
Cost of returning to work (Male)	ϕ_a^H	0.258 *(0.020)*
Cost of returning to work (Female)	ϕ_a^W	0.724 *(0.050)*
Standard Deviation of Leisure shocks (Male)	σ_P^H	0.001 *(0.000)*
Standard Deviation of Leisure shocks (Female)	σ_P^W	0.001 *(0.000)*

[a]Standard errors are in parentheses.

Table 11: Parameter estimates: earnings offers

Name	Symbol	Male[a]	Female[a]
Covered sector constant	α_C^i	-0.565 *(0.025)*	-1.364 *(0.026)*
Uncovered sector constant	α_U^i	-1.060 *(0.012)*	-1.789 *(0.014)*
Cohort effect	θ^c	0.050* *(0.005)*	0.050* *(0.005)*
Returns to education (Covered sector)	$\theta_{E,C}^i$	0.085 *(0.009)*	0.067 *(0.015)*
Returns to education (Uncovered sector)	$\theta_{E,U}^i$	0.119 *(0.009)*	0.085 *(0.014)*
Returns to covered experience	$\theta_{X,C}^i$	0.020 *(0.001)*	0.045 *(0.002)*
Returns to uncovered experience	$\theta_{X,U}^i$	0.023 *(0.001)*	0.039 *(0.002)*
Experience-schooling interaction	$\theta_{X,E}^i$	0.003 *(0.000)*	0.005 *(0.000)*
Experience-schooling interaction (College graduates)	$\theta_{X,E}^i$	0.018 *(0.001)*	0.005 *(0.001)*
Experience transferability	τ_{XP}^j	0.971[b] *(0.111)*	0.971[b] *(0.111)*
Sd of shocks to earnings offers (Covered)	σ_C^i	0.219 *(0.013)*	0.208 *(0.031)*
Sd of shocks to earning offers (Uncovered)	σ_U^i	0.265 *(0.023)*	0.134 *(0.022)*

[a] Standard errors are in parentheses.
[b] Cohort effects and experience transferability were constrained to be equal across gender and sectors to reduce the number of parameters to be estimated.

Table 12: Parameter estimates: probability of receiving a covered offer

Name	Symbol	Male[a]	Female[a]
Constant	γ^i	1.999 *(0.334)*	2.167 *(0.548)*
Schooling level	γ_E^i	0.999 *(0.170)*	0.881 *(0.254)*
Covered Job at t-1	γ_{Cov}^i	0.098 *(0.046)*	0.995 *(0.411)*
Covered experience	γ_{XP}^i	0.029 *(0.009)*	0.072 *(0.028)*

[a] Standard errors are in parentheses.

Table 13: Parameter estimates: types logit parameters

Name	Symbol	Type 1[a]	Type 2[a]	Type 3[a]
Constant	$\lambda(\psi)$	-1.310[b]	1.899 *(0.205)*	0.019 *(0.067)*
Schooling level (Husband)	$\lambda_E^H(\psi)$	0.701[b]	-0.207*(0.066)*	-1.203 *(0.387)*
Schooling level (Wife)	$\lambda_E^W(\psi)$	0.001[b]	-0.339 *(0.079)*	-1.201 *(0.284)*
Cohort	$\lambda_E^C(\psi)$	0.002[b]	-0.298 *(0.057)*	1.042 *(0.100)*

[a] Standard errors are in parentheses.
[b] Since the type probabilities must sum to one, the coefficients of only two out of three Types can be identified so Type 1's coefficients were held fixed through estimation.

Table 14: Pension coverage rates by occupation and industry (source: Arenas de Mesa et al. (2004))

Occupation		**Industry**	
Defense and police	97%	Agriculture	45%
Managers	42%	Mining	87%
Non-skilled workers	53%	Manufacturing	71%
Technicians	80%	Electricity,gas and water	87%
White collar workers	86%	Construction	58%
Sales and service workers	59%	Trade	53%
Agricultural workers	39%	Transport and Com.	59%
Blue collar workers	55%	Financial Services	78%
Machine operators	68%	Services	68%
Employment Category		**Labor Contract**	
Self-employed	17%	Yes	94%
Wage Worker	78%	No	19%
Domestic Service	44%		

Table 15: Change in uncovered sector participation under no-segmentation counterfactual.

	Coverage rate			
	Baseline	$\Gamma_i^t = 1$	**Change** (Pct. Points)	**Change** (As % of Uncov. sect.)
By Education				
No Highschool	62.4	70.8	+ 8.4	22%
Highschool dropout	68.2	72.5	+ 4.3	14%
Highschool graduate	72.3	75.4	+ 3.0	11%
College graduate	77.8	79.3	+ 1.5	7%
Total	69.9	74.0	+ 4.1	14%

Table 16: Contribution rates and pension coverage

Contribution rate	**5%**	**7.5%**	**10%**	**12.5%**	**15%**	**20%**
Husbands' coverage						
% covered[a]	74.4	72.3	69.9	67.7	66.0	61.1
Wives' coverage						
% covered[a]	33.4	32.7	30.3	27.6	26.0	23.7
Safety net						
% eligible husbands[b]	39.2	11.3	5.1	3.8	4.3	4.6
% eligible wives[b]	27.9	14.3	8.0	5.2	5.0	4.9

[a] Fraction working in the covered sector in the simulated 2004 cross section under alternative contribution rates.
[b] Each household in the sample is simulated until retirement to determine eligibility of either spouse to safety net benefits.

Table 17: Effect of the contribution rate on contribution densities

	Fraction of Husbands[b]			**Fraction of Wives**[b]		
Contribution rate	**10%**	**15%**	**Δ**	**10%**	**15%**	**Δ**
Contribution densities[a]						
0-25%	20.1	25.0	*+4.9*	66.5	73.8	*+7.3*
25-50%	11.0	11.7	*+0.8*	12.6	7.0	*-5.6*
50-75%	14.6	11.4	*-3.2*	7.7	5.7	*-2.0*
75-100%	54.3	51.9	*-2.5*	13.2	13.4	*+0.3*
Total	100.0	100.0		100.0	100.0	

[a] Contribution densities are defined as the number of years working in the covered sector over the total number of years since age 16.
[b] Fraction in the simulated 2004 cross section whose contribution density lies in the corresponding range.

Table 18: Contribution rates and savings

Contribution rate	**5%**	**7.5%**	**10%**	**12.5%**	**15%**	**20%**
Private savings						
mean[a] (million pesos)	8.3	7.3	7.0	6.6	6.4	5.9
Husbands' pension savings						
mean[a] (million pesos)	1.1	2.1	3.0	3.9	4.8	6.3
Wives' pension savings						
mean[a] (million pesos)	0.3	0.5	0.7	0.9	1.1	1.4
Total Savings						
mean[a] (million pesos)	9.7	9.9	10.8	11.5	12.2	13.6

[a] Mean for the simulated 2004 cross section under alternative contribution rates.

Table 19: Alternative safety net designs and sector choice

	Baseline	**2008 Reform**	**Universal**	**Top-up**	**High Taper rate**
			% Husbands Covered[a]		
Age					
20-29	77.8	77.3	77.4	77.6	77.1
30-39	79.5	78.9	78.9	79.0	78.8
40-49	81.7	81.6	81.6	81.3	81.5
50-59	77.9	78.2	77.9	77.9	78.2
60-64	71.7	71.4	71.7	71.8	71.4
			% Wives Covered[a]		
Age					
20-29	65.8	65.0	65.0	65.1	65.1
30-39	74.7	73.1	73.1	74.3	73.6
40-49	73.3	69.1	69.5	69.9	69.7
50-59	65.6	64.9	63.4	62.8	64.7

[a] To obtain a representative cross-section in which all households have only worked under the new Chilean system, lifetime decisions are simulated until 2039. For new generations entering the labor market between 2007 and 2039, initial conditions are drawn from the initial conditions of the last cohort in the sample.

Table 20: Alternative safety net designs and labor force participation

	Baseline	**2008 Reform**	**Universal**	**Top-up**	**High Taper rate**
			% Husbands working*		
Age					
20-29	98.0	97.7	97.7	97.7	97.7
30-39	98.7	98.6	98.6	98.6	98.6
40-49	97.4	97.2	97.3	97.2	97.3
50-59	94.5	94.4	93.4	93.3	94.4
60-64	34.3	33.8	33.7	33.7	33.9
			% Wives workings*		
Age					
20-29	39.3	38.2	38.0	38.5	38.3
30-39	47.6	45.1	44.9	46.0	45.5
40-49	46.0	41.2	41.0	42.1	41.6
50-59	43.0	35.8	34.7	36.1	36.3

[a] To obtain a representative cross-section in which all households have only worked under the new Chilean system, lifetime decisions are simulated until 2039. For new generations entering the labor market between 2007 and 2039, initial conditions are drawn from the initial conditions of the last cohort in the sample.

Table 21: Fiscal impact of alternative safety designs

	Income tax revenue[a]	**Pension Benefit Outlays**[a]
Baseline	100	100
2008 Reform	105.1	205.7
Universal Pension	105.3	246.0
Top-up	102.6	177.9
High Taper rate	104.3	187.4

[a]To obtain a representative cross-section in which all households have only worked under the new Chilean system, lifetime decisions are simulated until 2039. For new generations entering the labor market between 2007 and 2039, initial conditions are drawn from the initial conditions of the last cohort in the sample.