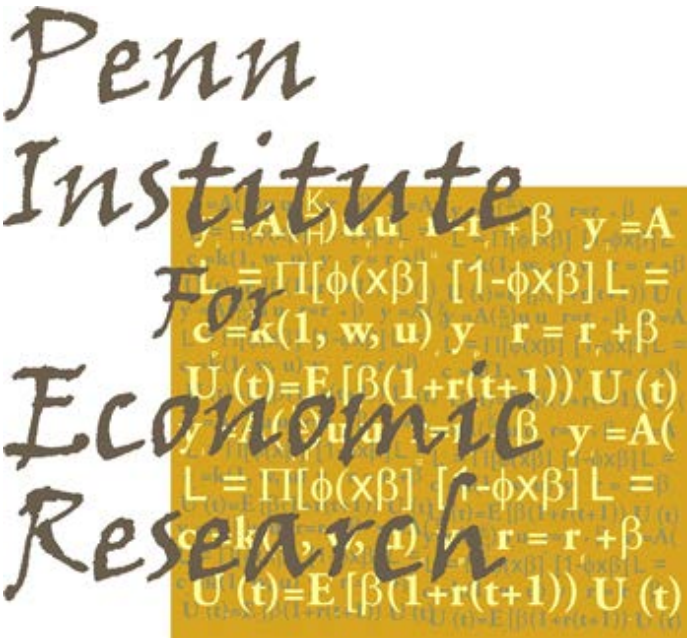

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"Pension design with a large informal labor market: Evidence from Chile"

by

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

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Abstract

This paper investigates empirically the fiscal and welfare trade-offs involved in designing a pension system when workers can avoid participation by working informally. A dynamic behavioral model captures a household's labor supply, formal/informal sector choice and saving decisions under the rules of Chile's canonical privatized pension system. The parameters governing household preferences and earnings opportunities in the formal and the informal sector are jointly estimated using a longitudinal survey linked with administrative data from the pension system's regulatory agency. The parameter estimates imply that formal jobs rationing is limited and that mandatory pension contributions play an sizeable role in encouraging informality. Our policy experiments show that Chile could achieve a reduction of 23% of minimum pension costs, while guaranteeing the same level of income in retirement, by increasing the rate at which the benefits taper off.

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

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1 Introduction

On average among countries worldwide, one third of economic activities are informal.[1] That is, they are concealed from public authorities to avoid paying taxes and social security contributions and, more generally, elude regulation.[2] The existence of large informal economies poses formidable challenges for the design of a pension system. Higher informality rates imply lower pension contributions and tax revenue, and may increase the elderly's reliance on costly safety nets. At the same time, mandatory pension contributions and retirement income transfers can themselves create incentives for workers to avoid formal employment, making it hard to reconcile stated program goals such as old-age poverty reduction and budget balancing (Piggot et al., 2009). This paper investigates empirically the fiscal and welfare trade-offs involved in designing a pension system when workers can avoid participation by working informally.

A dynamic behavioral model captures a household's labor supply, formal/informal sector choice and saving decisions under the rules of Chile's canonical privatized pension system. The model builds upon the dynamic occupational choice model of Keane and Wolpin (1997), interpreting the formal and informal sectors as occupational sectors. It extends that framework by allowing for endogenous labor force participation of both spouses, pension and non-pension savings accumulation and labor market segmentation.[3] The model incorporates the key institutional features of the pension system as well as rich observed and unobserved heterogeneity, so as to best capture the economic

[1] Schneider (2011).

[2] This definition of informality is concerned with legal market-based activities and thus does not include criminal activities or home production.

[3] See section 3 for a discussion of these features in relation to the existing literature.

margins affected by the pension rules. The parameters governing household preferences and earnings opportunities in the formal and the informal sector are jointly estimated by the method of simulated moments. We use a unique data set of longitudinal observations on a representative sample of Chilean households linked with administrative data from the pension system's regulatory agency. The estimated model is then used to study the effects of changing the rules governing pension contributions and benefits on the behavior and welfare of households and on program costs.

Over the last three decades, many governments have considered or introduced fully-funded, privately-managed, individual accounts-based pension programs.[4] Chile was the earliest and most influential example of such a reform in 1980, and the only one for which more than 29 years of data are available.[5] Under Chile's pension program, workers must contribute 10 percent of their earnings to an individual account that is managed by private pension fund managers and converted into a monthly pension benefit upon retirement. Individual pension accounts establish a transparent link between contributions and subsequent retirement benefits. This feature can theoretically reduce the wage distortions created by mandatory pension contributions, thus increasing pension program participation and reducing informality.[6] This paper examines the quantitative relevance of these distortions by simulating how households adjust their savings, consumption and formal sector participation to changes

[4]The traditional paradigm is a pay-as-you-go pension program that uses contributions from current workers to pay for the current retirees' benefits. These programs also tend to be state-run and to offer guaranteed or "defined" benefits conditional on a given employment history.

[5]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.

[6]Corsetti and Schmidt-Hebbel (1997).

in the contribution rate.

Individual-accounts saving programs are usually combined with a noncontributory government-provided safety net that aims to guarantee a minimum income level for the elderly.[7] Such benefits can impact individual decisions in at least two ways that are captured by our model. First, they induce a wealth effect that could depress savings and labor supply. Second, accumulated pension savings through the mandatory contributions program decrease minimum pension benefits at a certain rate. This benefit "tapering" lowers the value of formal work by creating an implicit tax on pension contributions. Our second series of policy experiments compares program costs and behavioral impacts over a range of tapering rates including the one implemented by Chile in a 2008 reform of its safety net programs.

The estimated imply that barriers to entry into the formal sector (i.e. "rationing") are modest on average, though they account for up to 21% of informal sector participation among male workers with the lowest schooling attainment. In addition, work experience is highly transferrable from one sector to the other. Overall, these findings are consistent with the "competitive" (as opposed to "segmented" or "residual") view of the informal sector put forward by recent non-structural studies.[8]

We find that mandatory pension contributions can create significant evasion to the informal sector. According to our simulations, raising the contribution rate by 5% increases the size of the informal sector by 12.5% for men (9.3% for women). It also decreases household welfare by lowering average household

[7] "Contributory pensions" refer to pensions benefits funded by the workers' accumulated contributions. Non-contributory benefits are usually funded by the government.

[8] See Maloney (1999); Gong et al. (2004); Gong and Van Soest (2002).

consumption by 4% and increasing lifetime consumption volatility by 11.9%. From the government budget's point of view, the lowest program costs are achieved at a 7.5% contribution rate, rather than Chile's current 10% rate. Even though a higher rate reduces minimum pension benefit outlays, it also decreases tax revenue due to higher informality rates. In a second series of experiments, we set the minimum pension benefit at the level implemented in the 2008 reform and consider the effect of changing the taper rate. The 30% taper rate chosen for the 2008 Chilean reform turns out to be the one that maximize tax revenue, by optimizing labor supply incentives. However, paid benefits are also 42% higher in that case than under a 100% taper rate. Taking into account both tax revenue and paid benefits, the cheapest design implements a 60% taper rate, for a 23% reduction in costs.

The paper is structured as follows. Section 2 provides background information on the Chilean pension system, discusses the normative framework of the paper and the data used in estimation. Section 3 describes the estimation sample and our measure of informality. Section 4 lays out the dynamic behavioral model and discusses identification. Section 5 contains the estimation procedure and model fit. Section 6 shows the results from the policy experiments. Section 7 concludes.

2 Institutional background

2.1 Chile's 1980 pension system privatization

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. 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 1980 reform was motivated by a vicious circle of chronic deficits, that represented 40% of benefit payments in 1980. These deficits led to skyrocketing contribution rates (over 50% of a worker's monthly remuneration in 1974), which in turn increased payment evasion (the ratio of active contributors over people in work fell from 83 in 1973 to 71 in 1980), and accentuated the decline in the contributors-to-pensioners ratio (3.5 in 1973, 2.2 in 1980).

Individuals in the old pension system were given the option of transferring to the new AFP system, based on individual capitalization, or to remain in the old system (now called the INP system).[9] To encourage transfers, workers who opted for the new system received a 12.6% increase in net income (the new contribution rate plus commissions or fees) and the benefits accrued under the old system were recognized through the issuing of a "recognition bond," payable upon retirement. Labor force entrants after 1980 were required to affiliate to the new system.[10] By the end of 1983, 77% of workers from the old system had switched to the new one (Acuña and Iglesias (2001)).

The main component of the new AFP pension system is a "privatized" savings program based on privately-managed, defined-contribution, fully-funded

[9]INP= *Instituto de Normalizacion Previsional*.

[10]Government and military workers are exempted and have separate pension systems.

individual accounts.[11] 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 they become eligible to claim pension benefits.[12] The worker can choose from a number of pension fund administrators (the AFPs) who manage the savings deposited in the account and invest them in the financial markets.[13] 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.[14] 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.[15]

[11] "Defined-contributions" (as opposed to "defined-benefits") means that the level of benefits received in retirement, conditional on a given employment history, is not guaranteed by the program; "fully-funded" (as opposed to pay-as-you-go) means that a worker's contributions are not used by the state to pay for current retirees' benefits. Instead, they are invested until the worker claims her pension benefits.

[12] 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.

[13] 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.

[14] 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 in volume.

[15] The law allows for early benefits claiming, 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.

2.2 Chile's minimum pensions and the 2008 reform

Prior to the 2008 pension reform, the state provided noncontributory retirement income transfers through two mechanisms. First, a welfare or assistance pension, known as the *PASIS* pension, equal to a little less than a third of the minimum wage was available for program applicants 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.[16] The second transfer was a minimum pension guarantee (MPG) equal to about twice the PASIS pension. Individuals with more than 20 years of contribution received the MPG if their accumulated contributions could not finance a higher pension. Both of these benefits took the form of a top-up, that is, the government transfer was equal to the difference between the guaranteed level and the pension financed by the worker's account.

In 2008, the pension system underwent significant reforms aimed at alleviating old age poverty and reducing gender gaps in pension accumulations. An analysis of pension contribution histories at the micro level (e.g. Arenas de Mesa et. al. (2007)) showed that most individuals were expected to have low pension accumulations upon retirement.[17] In particular, around half of Chile's workers would have pensions below the government's minimum pension guarantee but wouldn't qualify for it because of an insufficient number of years of contributions.

[16] In August 2007, the minimum wage was 159,000 pesos per month, while the PASIS was 44,186 pesos for retirees between 65 and 70 years of age, 47,103 pesos between 70 and 75 and 51,503 pesos if older than 75. The PASIS pensions were allocated based on an index of economic vulnerability, called "ficha CAS".

[17] The micro-level data on pension contribution histories were obtained from a database of the pension fund regulatory agency, the *Superintendency of Pensions* or SP. These are the same data as used in this paper.

The reform replaced the PASIS pension and the minimum pension guarantee (MPG) with a so-called "New Solidarity Pillar" that augments the pension levels of workers with relatively few years of contributions. The new safety net implements a means-tested welfare pension, which guarantees to all individuals in the 60% least affluent households a pension of 75,000 pesos per month called *Pension Basica Solidaria*, or PBS. This feature was introduced gradually over July 2008-July 2011.[18] The PBS represents an increase of nearly 50% with respect to the former PASIS pension and is above Chile's poverty line. In addition to providing a minimum pension level, the new system augments low contributory pensions through the Solidarity Pension Supplement or APS.[19] The APS benefit corresponds to a fraction of the PBS that is gradually reduced for workers with relatively larger contributory pensions according to the formula:[20]

$$APS = PBS * \left(1 - \frac{Contributory\ Pension}{Maximum\ Supplemented\ Pension}\right).$$

In effect, this means that the APS tapers off at a rate that reached 0.3 in July 2011. For example, a worker who can finance a pension of 100,000 pesos per month with the funds accumulated in her individual account will receive a supplement equal to $75,000 - (100,000 * 0.3) = 45,000$. Her total pension will then be 145,000 pesos per month.

[18] The level of the PBS was initially 60,000 pesos and reached 75,000 pesos in July 2009. The coverage of the PBS was started at 40% with eligibility being based on an existing poverty index, the Social Protection Index (*Ficha de Proteccion Social)*. Coverage reached 60% in July 2011 and eligibility will be based on the household's income from September 2009 onwards.

[19] *Aporte Previsional Solidario*.

[20] The Maximum Supplemented Pension (PMAS or *Pension Maxima con Aporte Solidario*) was gradually increased through the phased implementation from 70,000 pesos per month to 255,000 pesos per month in July 2011.

2.3 Normative framework of this study

In Chile's "fully-funded" individual-accounts savings program, a worker funds her pension benefits with her own accumulated contributions. As a result, the system is financially insulated from the country's demographic fluctuations. This feature constitutes the main appeal of individual-accounts systems for countries with aging populations. The main hurdle to adopting a fully-funded system is the huge cost incurred by the government during the transition to the new system.[21] Privatization advocates also argue that the returns on pension contributions obtained on the financial markets typically exceed the implicit returns generated in a pay-as-you-go system.[22]

A number of macroeconomic studies have evaluated the merits of these arguments.[23] They typically use calibrated overlapping-generations models that are well equipped to assess equilibrium effects on wages, asset returns and the government budget, and to take into account transitions between steady-states. Our complementary approach is to investigate in greater depth partial equilibrium impacts of rule changes within the context of a privatized pension system. By setting this more modest goal, we can move beyond calibration on aggregate and cross-sectional data to estimation on longitudinal microeconomic data. We consider rich observed and unobserved heterogeneity (age, schooling, formal and informal experience, preferences and productivity) and detailed institutional features. Our behavioral model's precise theoretical description of

[21] That cost is equal to the pension rights accumulated by workers and retirees at the time of the reform, which can no longer be paid for with pension contributions since these are redirected towards the individual accounts.

[22] Returns on pension savings in a pay-as-you-go are equal to the growth rate of national labor income.

[23] See for example Auerbach and Kotlikoff (1987), Conesa and Krueger (1999), and Nishiyama and Smetters (2007).

the economic margins affected by pension rules (including labor supply, formal sector participation and savings accumulation) can then be confronted to similarly detailed data. In addition to the fiscal cost of actual and counterfactual designs (net of changes in tax collection), we report their impact on the following outcomes: participation in the formal and informal labor markets, savings, household consumption and consumption volatility.

The implicit objective function in our analysis is to minimize government costs while guaranteeing a minimum consumption level in retirement that is above the poverty line. This is also our interpretation of the policy makers's goals in implementing the 2008 reform.[24] Given the insurance gains achieved by the minimum pensions, mandatory savings can be justified as a way to limit the attached moral hazard problem despite distorting household decisions.[25] The overall system can thus be welfare-improving if lifetime income risk is large and difficult to insure against in the private market. An alternative rationale hypothesizes that individuals do not save optimally and must be forced to do so by the pension program. The model incorporates the possibility that some households are myopic: with some estimated type-specific probability, a household's discount factor is 0. These households accumulate little savings but in doing so they are still behaving optimally given their preferences.[26]

[24]In particular, the 2008 reform's new minimum pension is about equal to Chile's poverty line. Also, the choice of a tapered benefit was explicitly motivated as a way to minimize tax and contribution evasions potentially associated with large implicit marginal taxes.

[25]In other words, pension contributions prevent workers from under-saving in order to qualify for larger transfers.

[26]A few empirical studies incorporate time-inconsistent preferences to generate individually suboptimal saving behavior (see for example Fang and Silverman, 2009).

3 Data

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)). 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.[27]

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.

3.1 Estimation sample

The sample used in the estimation is restricted as follows. First, we keep 8193 married and cohabiting couples that have been together at least from 2002 to 2006. We only consider cohorts that were subject only to the post-1980 privatized pension system. Couples formed after the husband turned 25 were also dropped to avoid having households with significant asset accumulation

[27]The 2009 follow-up survey was administered in the course of 2009 and was not used in this study.

and work experience prior to marriage, since initial conditions are kept fixed in the policy experiments. This leaves 2314 couples. After eliminating couples with missing initial conditions, couples in the old INP pension system, and asset and wage outliers, the final sample consists of the 2097 households.[28] The oldest cohorts are observed from the age of 18 to the age of 51, while the youngest cohorts are observed only one or two years (see Table 2).

Table 3 presents summary statistics and documents the effect of sample restrictions. The first column corresponds to the estimation sample, the second column applies only restrictions related to marital status, age and cohort and the third column represents the initial EPS sample respondents ages 20 to 50. Comparing the first two columns, we can see that the effect of restrictions related to missing data and outliers is minimal on all statistics. Comparing the third column with the first two, it is apparent that excluding single individuals and older cohorts has a modest impact on earnings and sector choice. Unsurprisingly, more women engage in home production in our sample (52.2%) than in the EPS sample (37.9%) due to the exclusion of singles. Schooling is also higher in the EPS sample as educated individuals marry and cohabit later on average. These single educated individuals push median private asset levels between 20 and 29 up in the EPS sample relative to the estimation sample. The differences in median pension savings is a desirable feature: the older cohorts spent a fraction of their work life under the pre-1980 system; their limited pension saving accumulations in the new system push the median towards 0.

[28]To eliminate outliers, we trimmed 1% on each tail of the wealth distribution, 0.2% on the right tail of the earnings distributions and 0.1% on the right tail of the pension savings distribution.

3.2 Measuring informal sector participation

The variables used in the estimation are age, schooling level, schooling level of the spouse, number of years the respondent worked in the formal sector, number of years the respondent worked in the informal 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, with the exception of informal sector participation, which we discuss next.

Schneider, 2011 defines the informal sector as market-based economic activities that are concealed from public authorities to avoid paying taxes and social security contributions and, more generally, elude regulation. Note that per this definition informality does not include criminal activities or home production. Microeconomic studies in the literature use a variety of measures of informal sector participation, the most common of which are: size of the employing firm, payment of pension contributions (sometimes known as pension coverage), the signature of an employment contract. From the public finance point of view adopted in this paper, as captured in our model, the second measure is the most relevant. The only institutional difference between formal and informal employment opportunities in our model are the payment of pension contributions and taxes.

Table 4 reproduces a number of characteristics associated with pension coverage gathered by Arenas de Mesa et al., 2004 using the EPS 2004 data set. Notice in particular that salaried workers who sign a contract have a pension coverage rate of 94%. While EPS respondents are asked directly whether they pay pension contributions, this subjective measure might not be reliable since

employers are in practice paying pension contributions on behalf of their employees. Contract signatures are likely to be better remembered so we use that indicator to classify salaried employment spells as formal or informal. In the time period covered by our data, self-employed workers were not required to make pension contributions and only 17% did as seen in table 4. Since in our model pension contributions are mandatory in formal jobs, we group self-employed workers with informal workers. An alternative interpretation of the two sectors in the model is jobs that are either "covered" or "uncovered" by the pension system.

4 The Model

The model represents the decision problem of a couple.[29] The optimization problem starts when the couple is formed ($t = t_0$). A period corresponds to a calendar year and is indexed by the husband's age.[30] The maximum attainable age for the household is set to $t_D = 100$ but both spouses face mortality risk every period. Death of either spouse results in the end of the optimization problem and a terminal value V_D.

After reaching the legal retirement age $t_R = 65$ (or earlier if they qualify for early benefits claiming), spouses start receiving their pension benefits but are allowed to keep working until age $t_W = 74$.[31] At each working age $t \in$

[29] We use the husband/wife terminology in both cases for simplicity even though the model is applied to married and unmarried couples.

[30] Not keeping track of the age of the wife crucially reduces the size of the state space. The model assumes that both spouses claim benefits simultaneously, when in reality the legal retirement age is 60 for women and 65 for men. Implicitly the model assumes that the wife is 5 years younger than her husband which is roughly the average age difference between spouses in the sample.

[31] The fraction of individuals working past that age in the data is around 3%.

$\{t_0, ...t_W\}$, 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 formal sector ($d_t^j = 1$), to work in the informal sector ($d_t^j = 2$), or to stay home ($d_t^j = 3$).

Couples form a unitary household with a single common period utility function. They care about total household consumption through a CRRA term. Non-pecuniary benefits derived from leisure or from working in a particular sector are captured by δ_k^H and δ_k^W. δ_C denotes complementarity in leisure between the spouses. Finally, they pay a cost when switching between formal and informal 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 $t \in \{t_0, t_D\}$, the period utility function is given by:

$$\begin{aligned} u(c_t, d_t) &= \frac{c_t^{1-\sigma}}{1-\sigma} + \sum_{j=H,W} \sum_{k=1,...3} (\delta_k^j + \epsilon_k^j(t)) \cdot I_{\{d_t^j = k\}} + \delta_C \cdot I_{\{d_t^H=3\}} \cdot I_{\{d_t^W=3\}} \\ &+ \phi_s^H \cdot (I_{\{d_t^H=1, d_{t-1}^H=2\}} + I_{\{d_t^H=2, d_{t-1}^H=1\}}) + \phi_a^H \cdot I_{\{d_t^H \neq 3, d_{t-1}^H=3\}} \\ &+ \phi_s^W \cdot (I_{\{d_t^W=1, d_{t-1}^W=2\}} + I_{\{d_t^W=2, d_{t-1}^W=1\}}) + \phi_a^W \cdot I_{\{d_t^W \neq 3, d_{t-1}^W=3\}}. \quad (1) \end{aligned}$$

where the shocks to the value of leisure are assumed to be distributed normally and to be mutually serially uncorrelated:

$$(\epsilon_t^H, \epsilon_t^W) \sim iidN(0, \Sigma_p). \quad (2)$$

The model's state variables are the following: a_t denotes the household's non-retirement or non-pension 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; $X_{I,t}^H$, $X_{I,t}^W$, $X_{F,t}^H$ and $X_{F,t}^W$ are the four stocks of sector-specific experience, with the subscripts F

and I denoting the formal and informal 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. bc is the birth cohort of the husband.

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

$$V_t(\Omega_t) = \sum_{\tau=t}^{t_D} \beta^{\tau-t} \quad u(c_\tau(\Omega_\tau), d_\tau(\Omega_\tau)), \tag{3}$$

where $\Omega_t = \{a_t, B_t^H, B_t^W, E^H, E^W, X_{F,t}^H, X_{I,t}^H, X_{F,t}^W, X_{I,t}^W, d_{t-1}, bc\}$.

Households face a two-sector labor market with a formal and an informal sector. The two sectors are indexed by $j \in \{F, I\}$. Each spouse may receive a stochastic earnings offer from the formal 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 informal sector with probability 1. The probability Γ_t^i for spouse i to receive an earnings offer from the formal sector in period t captures the possibility that there is excess supply of labor in the formal sector, so that some workers might be rationed out of the formal sector. Γ_t^i is a logistic function of education, the number of years of formal experience, and having been employed in the formal sector in the previous period:

$$\Gamma_t^i = \left(1 + e^{-\left(\gamma^i + \gamma_F^i I_{\{d_{t-1}^i = 1\}} + \gamma_E^i E^i + \gamma_{XP}^i X_F^i\right)}\right)^{-1}. \tag{4}$$

The log-earnings offers (for spouse $i \in \{H, W\}$, in sector $j \in \{F, I\}$) are

given by

$$w^i_{j,t} = \alpha^i_j + \theta_{bc} bc + \theta_a t + \theta_{a2} t^2 + \theta^i_{E,j} E^i + \theta^i_{X,j}(E^i)(X^i_j + \tau_{XP} X^i_{-j}) + \epsilon^i_{j,t}, \quad (5)$$

where α^i_j is a gender- and sector-specific constant, θ_{bc} a cohort effect, $\theta_{E,j}$ the returns to schooling, $\theta^i_{X,j}(E^i)$ are the returns to experience. An unrestricted specification would have formal and informal experience terms (linear and quadratic) in both the formal and informal log-earnings offer equations, for both spouses. We economize on the number of parameters by assuming that returns to cross-sector experience are a fixed fraction τ_{XP} of returns to same-sector experience and by having a quadratic polynomial in age. τ_{XP} captures how different the type of skills accumulated and rewarded in the two sectors are. When working in sector j, the returns to a year of experience in the other sector equal $\tau_{XP}\%$ of the returns to a year of experience in sector j. $\epsilon^i_{j,t}$ is an iid sector-specific earnings offer shock that is uncorrelated across time periods and potentially correlated within a household: $(\epsilon^i_{j,t})^{i=H,W}_{j=F,I} \sim N(0, \Sigma_o)$. The total household disposable labor income y_t is the sum of accepted earnings offers, net of contributions:

$$y_t = \sum_{i \in \{H,W\}} ((1-\tau) w^i_{F,t} \cdot I_{\{d^i_t=1\}} + w^i_{I,t} \cdot I_{\{d^i_t=2\}}), \quad (6)$$

where τ is the pension contribution rate.

Formal labor earnings net of pension contributions and non-pension savings returns are subject to a progressive income tax. Taxes due in period t are given

by:

$$T(y_t + ra_t) = \sum_{b=1}^{B} \tau_b \left(max\{0, min\{y_t + ra_t, \bar{y}_b\} - \bar{y}_{b-1}\} \right) \tag{7}$$

where B is the number of tax brackets, the $\bar{y}_b$s define the tax brackets, and τ_b is the marginal tax rate for bracket b.[32]

We make the following additional assumptions regarding assets accumulations. Returns on the pension accounts are modeled as an i.i.d. process estimated on the returns achieved since 1980 by Chilean pension fund managers.[33] Non-pension savings are modeled as a risk-free asset as in French and Jones (2011), French (2005) or Van der Klaauw and Wolpin (2008).[34] Lastly, we assume that households cannot have negative net levels of non-pension assets.[35]

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

[32]See table 1 for the actual bracket values and corresponding marginal tax rates.

[33]In reality individual returns will differ because people can choose different firms to administer their pension funds and choose different funds within those firms. These decisions are not incorporated into the model.Also, allowing for serial correlation in the returns would require adding past returns as additional continuous state variables, which would significantly complicate the model's numerical solution.

[34]The actual risk-return characteristics of non-pension savings are difficult to evaluate empirically, because households hold heterogenous assets outside of their pension account.

[35]This allows households to borrow up to the value of their assets, but not more. In particular, they cannot borrow against pension savings, which is not allowed in Chile. In the data, 6.2% of sampled households owe more than the median monthly earnings, and 0.3% owe more than the median annual earnings.

written recursively:[36]

$$
\begin{aligned}
V_t(\Omega_t) &= \max_{c_t,d_t}\{u(c_t,d_t)+\beta((1-(p_t^H+p_t^W))EV_{t+1}(\Omega_{t+1})+(p_t^H+p_t^W)V_D\} \\
&\quad s.t. \\
a_{t+1} &= y_t + a_t(1+r) - c_t - T(y_t + ra_t), \quad a_{t+1} \geq 0 \\
B^i_{t+1} &= B^i_t(1+r_B) + \tau w^i_{F,t} d^i_{F,t}, \ i \in \{H,W\}. \qquad (8)
\end{aligned}
$$

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. Given the continuation value function in period t, optimal consumption at $t-1$ is obtained for each value of the deterministic and shock components of the state space. This is done by comparing utility on a grid of possible consumption levels, for each of the nine possible choices of husbands' and wives' labor sectors. At each 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 interpolated outside of that subset by a regression on functions of the state variables as suggested in Keane and Wolpin (1994). The R-squared on these regressions average 99.6 over all periods and types, with a minimum of 97.6.

[36] In the empirical implementation, the value of becoming a widow or widower, V_D, is set at 0. This is innocuous to the extent that V_D is a constant and mortality risk is exogenous. We did not explore letting V_D depend on state variables to economize on the number of parameters to be estimated.

4.1 Model discussion and parameter identification

Two key features of the model determine the impact of pension system rules on household decisions: the mobility restrictions between the formal and informal sectors of the labor market (referred to as "segmentation") and the substitutability between pension and non-pension savings. Even though these two mechanisms interact in the model, it is useful to discuss separately how we parameterize and empirically identify each of these mechanisms.

4.1.1 Labor market segmentation

Empirically, wages tend to be systematically higher in the formal sector (see table 11) but the literature is divided on how to interpret this fact. The traditional view of informality sees it as evidence of formal jobs rationing.[37] In our decision model, this possibility is captured by the probability of a formal earnings offer arrival, modelled as a function of schooling, previous formal sector experience and lagged formal sector participation.

Later studies have argued that distinct wage equations across sectors can arise without any rationing. For example workers might self-select according to their comparative advantage as in the Roy model.[38] In our model, a worker's comparative advantage evolves as a function of her schooling level, her permanent unobserved heterogeneity type, her transitory earnings shocks and her accumulated sector-specific experience.

[37]This could result, for example, from minimum wage regulations that are enforced only in the formal sector (Fields, 1990).

[38]See Dickens and Lang (1985), Heckman and Hotz (1986), Magnac (1991), Gindling (1991).

In addition, the value of formal and informal work differs according to non-pecuniary characteristics which are captured by the δ_k^j. Thus, the gap between formal and informal wages can also be interpreted as a compensating wage differential by the model. Further, one key non-pecuniary difference is modeled explicitly. Namely, the fraction of formal wages paid towards mandatory pension contributions is unavailable for immediate consumption. This will make the informal sector relatively more attractive, particularly for budget-constrained individuals.

A contribution of this study is to empirically quantify these different interpretations of informality.[39] When considering identification, note that formal sector rationing can be interpreted as a search friction from the worker's perspective. Taber and Vejlin (2013) establish non-parametric identification in a dynamic labor supply model that incorporates non-pecuniary benefits, comparative advantage, human capital and search frictions.[40] Life-cycle patterns in informal sector participation are key to identifying formal sector rationing: low rationing implies that the fraction of workers employed in the higher-paying formal sector should increase relatively quickly over the life cycle. Conditional on the level of rationing, wage differences along transitions between sectors

[39]The other dynamic structural models that incorporate an informal labor market to study pension design do not allow for non-pecuniary benefits or segmentation, rather assuming that workers can move freely between sectors (Valdés-Prieto, 2008, Velez-Grajales, 2009). An exception is Robalino et al. (2008). They estimate their parameters using age profiles of the fraction of individuals in the formal, informal, unemployed and retired states, but do not use data on wages, assets, sector-specific experience or longitudinal transitions.

[40]Their model is set in continuous time and is more general than ours. For example the heterogeneity in our non-pecuniary benefits and comparative advantage components are only type- and sector-, rather than individual- and firm-specific as in Taber and Vejlin (2013). As a result, our "establishment types" (formal, informal) are observed for all workers in our survey without the need for employer-employee matched data.

then reveal non-pecuniary preferences for each sector. Comparative advantage, captured by the type-specific wage equation intercept, is identified from the longitudinal dimension of the wage panel (Heckman and Singer, 1984).

An assumption implicit in our model is that workers have realistic employment opportunities in both types of jobs. In support of this assumption, tables 7 and 8 show that switching between formal and informal jobs is common and that many workers are employed in both types of jobs over the course of their careers. In addition, table 4 show that informality is not limited to specific occupations or industries. Instead, a sizeable fraction of workers do not make pension contributions accross industry and occupation categories (with the reassuring exception of the "Defense and police" occupation).[41]

Another interesting aspect of the labor supply decision in our model is that it is made jointly by the two spouses. Van der Klaauw and Wolpin (2008) highlight the importance of allowing for income risk pooling within the household to accurately capture the incentives created by social pension programs.[42] In particular, spouses in our model may choose to work in different sectors to qualify for a minimum pension while at the same time avoiding over-saving. Having one spouse work in the informal sector can alleviate the reduction of disposable income resulting from mandatory pension contributions. Table 3 shows that a sizeable fraction of spouses work in opposite sectors.

[41] An additional issue is that workers and employers might agree to paying contribution on only a fraction of the worker's salary. We ignore this "intensive margin" of informality because non-compliance is not reported by workers or firms and because it would add an endogenous decision in our model.

[42] Other recent examples or models of retirement with joint labor supply decisions include Gustman and Steinmeier (2000), Gustman and Steinmeier (2002), Blau and Gilleskie (2006).

4.2 Savings and the implicit portfolio choice

The second important feature of the model in terms of policy implications is the ability of workers to accumulate both pension and non-pension savings. Households face an implicit choice of portfolio between a taxable liquid asset and a tax-deferred, illiquid asset. The relative value of each asset to the worker evolves over the life cycle as a function of the precautionary savings motive (i.e. self-insurance against income risk) and the retirement saving motive.[43] The CRRA parameter, α, and the discount rate β determine the strength of the two saving motives.

The effect of the two parameters on the age profiles of savings is markedly different. High values of β will unambiguously generate higher saving rates. On the contrary, in a finite-horizon model with CRRA preferences, the effect α on savings is theoretically ambiguous: α governs consumption-smoothing both over time and over realizations of income and asset return uncertainty. For example, a higher value of α implies higher saving rates if income *uncertainty* is high, but lower saving rates if the income *level* is low (relative to a worker's permanent income). Thus, different (α, β) combinations will imply different age profiles of savings. An additional source of identification is specific to our model because pension savings accumulation is tied to formal sector participation.[44] This implies that life cycle patterns in sector choice will also contain

[43] These concepts have been studied in the context of individual retirement accounts (IRAs) (Gale and Scholz, 1994, Engen et al., 1994, Engen et al., 1996, Hubbard et al., 1995). In particular, 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.

[44] In Chile, it is possible to contribute more than the 10% to one's pension account. These voluntary contributions are rare ($< 2\%$ of workers in any given month) so we economize on an additional decision variable by not modelling this option.

information on both risk aversion and the discount factor.

5 Estimation

We estimate the model using a Method of Simulated Moments estimator in which observations of discrete choices labor supply choices are easily combined with information on continuous state variables such as savings stocks. It also accommodates the fact that we do not observe all variables in all periods.[45] We use the approximated age-dependent value functions, conditional on the state variables, to simulate moments of the savings, sector-specific annual earnings, and labor sector choice distributions. For any candidate set of parameters, the moments are generated by simulating from initial conditions the lifetime decisions and outcomes of 10 "clones" of the $2,097$ couples in the estimation sample. The moments chosen to summarize the data can then be replicated from the simulated histories to form the MSM estimator.

The estimation procedure minimizes a weighted distance between the simulated moments and corresponding data moments. The weights are the inverses of the estimated variances of the data moments. The total number of moments is $M = 953$; the number of parameters to be estimated is $K = 75$. The MSM criterion was minimized on a cluster comprised of 36 CPUs using the asynchronous pattern search solver HOPSPACK (Plantenga (2009)). The moments of the joint distribution of savings, sector and labor force participation choices used to form the estimator are listed in appendix B. Parameter

[45] See Keane and Sauer (2010) for a method that accommodates missing state variables in a maximum likelihood estimation by using of unconditional simulations (also applied in Keane and Wolpin, 2001 and Keane and Sauer, 2009).

estimates and standard errors are reported in tables 12 through 15. We discuss the values of the key parameters jointly with the counterfactuals and policy experiments.

5.1 Initial conditions and unobserved heterogeneity

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

It is important to recognize the existence of permanent unobservable sources of heterogeneity affecting decision-making, so the model incorporates three unobserved discrete types a la Heckman and Singer (1984). A household's type affects the value of leisure and of working informally for both spouses, and the intercepts in each spouse's two wage equations. The household's discount factor is also type-specific. Also, with some type-specific probability, the household's discount factor is 0 so that the household behaves myopically.

The schooling attainments of each couple are the outcome of unmodeled endogenous decisions. To help mitigate the potential resulting bias, the probability that a household is a particular type is modelled as a logistic function of the schooling levels of the husband and the wife, and of the birth cohort of the husband. The model is solved separately for each type, and simulated

households draw a type in the initial period according to the logit model.

Table 5 reports the estimated proportions of the three types in the population and their characteristics. Forty-one percent of the households in the sample are type 1, fifty-eight percent are type 2 and less than two percent are type 3. Compared to type 2 households, type 1 households are older and less educated. They exhibit lower rates of formality and female labor force participation and lower levels of savings. 3.7% of type 1 households behave "myopically" (i.e. to have a discount factor equal to 0) instead of 0.5% of type 2 households. Type 3 couples constitute a very small minority. These are older and atypical couples in which the husband tends to be less educated than the wife. For type 3 couples both informality and female labor force participation are high.

5.2 Model Fit

Few studies attempt to estimate a model that combines the life cycle savings and labor force participation dimensions.[46] Unlike these existing studies we must also fit a sector choice, two types of savings accumulation and the joint decisions of the two workers in the household. Overall, the model is a good description of this complex data generating process.

As mentioned in our discussion of identification, it is important that the model predicts the increase in informality over the life cycle (table 6). This increase translates into the low levels of formal jobs rationing revealed by our parameter estimates. The model also describes joint household labor choices

[46]Other examples include French and Jones (2011), French (2005) and Van der Klaauw and Wolpin (2008).

well (table 9) except for the fraction of households in which both members are inactive which is underestimated.

Mobility between sectors is also captured well. The model reproduces the bimodal distribution of time spent in formal vs. informal jobs (i.e. the conditional contribution densities, see table 7). Table 8 shows that the fit of the individual transition matrices is also good for both genders.

As argued earlier, the separate identification of the elasticity of intertemporal substitution and the discount factor relies on the patterns in life cycle savings accumulation which are reproduced in table 10. Remarkably, the model is also able to generate most of the dispersion in non-pension savings and pension savings. It is likely that modeling two potential income earners helps capture that dimension in the data: households formed of two highly educated individuals will accumulate large amounts of pension and non-pension savings.

6 Results

6.1 Determinants of informality

We argue in section 4.1.1 that the nature of the informal sector is a key determinant of the effect of pension rules on program costs and tax revenue. For example, if higher wages in the formal sector reflect an excess demand for formal jobs ("rationing"), distortive pension rules will not create an exodus towards the informal sector. In column (2) of table 16, we set the probability of receiving a formal job offer to 1. Under this "no-rationing" scenario, informal sector participation decreases by 5.3 percentage points or 18.8% for men, and

4.3 percentage points or 12.9% for women relative to the estimated model. In other words, the rationing hypothesis is a significant but minor explanation of the informality phenomenon. That fraction ranges from 21.0% for men with no high school education to 5.5% for college educated women. This schooling and gender gradient is reflected in the estimated coefficients of the logistic model for formal offers (see table 14). A more educated worker, but also one who has worked many years in the formal sector (particularly if it is in the previous year), is less likely to have to wait for access to formal employment.

A second difference between sectors is the returns to skills. In columns (3) and (4) of table 16, we equate returns to observed and unobserved skills across the two sectors and find that informal sector participation goes up dramatically, particularly for women. This is because the estimated type-specific wage intercepts are higher in the formal sector for all types and genders (except type 3 women who are relatively more productive in the informal sector). Note that returns to schooling are higher in the informal sector for both men (12.0% vs. 8.6%) and women (6.8% vs. 8.5%). Taken together, these estimates imply that the formal/informal wage gap is always positive but highest among low schooling individuals. Experience transferability τ_{XP} is estimated to nearly perfect, at 99.6%, suggesting that sector-specific skills are not an important factor in keeping workers away from the formal sector.[47]

We find that non-pecuniary preferences, taxes and eligibility for the minimum pension guarantee are not important factors in explaining informal sector participation (columns (5), (6) and (7)).

[47]That is, returns to one year of cross-sector experience are equal to 99.6% of returns to one year of same-sector experience.

6.2 Effect of mandatory pension contributions

We start our policy analysis with the mandatory savings part of Chile's pension system. Our policy parameter of interest is the mandatory pension contribution rate. In an individual-accounts savings program, a worker sees her contributions accumulate and earn returns until they are used to purchase an annuity at retirement. This is in contrast to a pay-as-you-go system in which workers accrue pension rights by the government according to complex formulae that typically also operate a redistribution between categories of individuals. Proponents of privatization argue that this transparent link between contributions and benefits reduces economic distortions to a minimum. Our goal here is to evaluate the magnitude of these residual distortions.

In our model, mandatory contributions constrain household decisions in two ways. First, they impose a lower bound on the overall saving rate of the household. Second, they force it to save in an illiquid asset that can only be consumed after retiring. Households can respond to these constraints in three ways, the first being to simply reduce consumption during work-age years. The willingness of a household to transfer consumption to retirement years is governed in our model by the CRRA parameter - interpreted as the elasticity of intertemporal substitution - and by the discount rate. The discount rate and fraction of myopic couples are estimated at 6.93 and 3.69% for type 1, 6.76 and 0.47% for type 2 and 6.26 and 3.22% for type 3 households.[48] The elasticity of intertemporal substitution is estimated at 1.57, which is within the (wide) range of estimates found in the literature.[49] Table 18 shows that mean

[48]These discount rates are slightly higher than what is usually found in models estimated or calibrated on American data (usually under 0.05).

[49]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 1.40.

consumption remains relatively stable as the contribution rate is increased from five to ten percent, but it declines by almost ten percent as the contribution rate goes from ten to twenty percent. Median consumption shows a smaller effect because the change is concentrated in the left tail of the consumption distribution.

A second possible response for the household is to reduce non-pension savings to offset the forced pension savings. However this decreases its ability to self-insure against income fluctuations. The size of that response is determined jointly by the parameters governing income risk (including the arrival probability of formal offers) and the CRRA parameter, now interpreted as risk aversion. In table 18, as the contribution rate increases from five percent to fifteen percent, mean non-pension savings decline by 27% (from 9.2 million pesos to 6.7 million pesos). As the contribution rate increases further, mean non-pension savings remain stable, because households are reluctant to expose themselves further to negative income shocks. If Chile's government attempted to increase national savings using the contribution rate, our simulations imply that total pension and non-pension savings would not start to increase significantly before the rate reaches 12.5%.

Lastly, households can avoid contributions by seeking employment in the informal sector. This can be costly to the government because it reduces tax revenue. The strength of that response hinges on the level of formal-informal labor market segmentation analyzed in the previous section. Table 17 shows that men reduce their formal sector participation by 9.2 percentage points as the contribution rate increases from 5 to 20%. The effect is weaker among

women (7.3 percentage points) and concentrated among infrequent formal sector participants (i.e. with contribution densities between 0 and 24%). It is also stronger at higher contribution rates: 4.3 percentage points between 15 and 20% versus 1.5 between 5 and 10%.

We conclude by noting that the contribution rate has an ambiguous effect on government costs. High contributions reduce tax revenue as workers leave the formal sector. On the other hand, low contribution rates imply that more workers will become eligible to retirement income transfers. The cost of the (pre-2008) safety net would have been multiplied by 5 if the contribution rate had been reduced to 5% from the current 10%. Once changes in tax revenue are taken into account, 7.5% is the tax rate that minimizes net program costs (though the actual rate of 10% yields close to that minimum).

6.3 Minimum pension design

In this section, we assume that the objectives of the safety net designer are to guarantee a minimal level of income to retirees while keeping costs low. We use the minimum pension level implemented by the 2008 reform as that desired minimum income. After fixing that level, the key policy parameter is the rate at which the benefit is reduced as a function of the worker's pension savings accumulations. This feature is called "claw-back" or "tapering'. It is intended to reduce the cost of the program but it also creates an implicit tax on pension contributions that lowers the value of formal work.

In this policy experiment, we simulate four safety net designs that are illustrated in figure 1. The first design keeps the 100% taper rate of the pre-2008 system but implements the 2008 reform's minimum benefit level. It corresponds

to the flat dashed line in the figure. The second, third and fourth designs keep that benefit level constant, but the rate at which the benefit is tapered is gradually decreased to 60%, 30% and 0%. The corresponding lines in the figure become steeper and steeper. In particular, the third design corresponds to the actual 2008 reform's design, and the fourth design is called a universal pension.

We consider the long term effects of the different rules. We simulate our sample's lifetime decisions under each scenario, from the couple's formation until every worker in the sample has retired and her pension rights are determined.[50] For each household, we then compute the 2006 present discounted value of the lifetime benefits received, and lifetime taxes paid.

6.3.1 Assumptions

Given that they are primitives of the model, the estimated preference parameters are taken as invariant to policy changes. However, the prices in the labor and capital markets might in theory be subject to equilibrium adjustments when pension rules are changed. The labor force participation effects found in this paper's counterfactual experiments are not quantitatively likely to dramatically impact equilibrium sectoral wages. Still, they should be interpreted as partial equilibrium effects. We invoke the assumption that Chile is a small open economy to justify the absence of equilibrium effects on asset returns. The initial conditions of the model, particularly the joint distribution of schooling levels among husbands and wives, also remain fixed through the policy simulations. In reality, it is possible that the endogenous schooling and

[50]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.

marital matching decisions could respond to the rules of the pension system. Lastly, the policy experiments we consider do not endogenize the changes in tax required to balance the government budget. In that way, our results are not conditioned on arbitrary assumptions on the progressivity of the tax rate, for example.

6.3.2 Findings

Table 19 reproduces program costs and tax revenues under each design (note that we normalize tax revenue under the first scenario to 0). Implementing a lower tapering rate is unambiguously more expensive: the 0% taper rate design in column (4) is twice as costly as the 100% taper rate design in column (1).

By contrast, the effect on tax revenue is bell-shaped. This reflects the interaction of two opposing effects. A lower taper rate reduces the implicit marginal tax *rate* which improves incentives for formal work and has a positive effect on tax revenue. On the other hand, the tax *base* (i.e. the fraction of households qualifying for the minimum pension) increases, which has the opposite effect on tax revenue. In other words, a lower taper rate effectively "spreads" out the implicit tax on a larger number of households. The simulations suggest that the design chosen by the Chilean policy-makers (column (3)) is the indeed the most incentive-compatible, in the sense that it generates the highest tax revenue. However, it is also about 40% costlier than a pure top-up design with a 100% taper rate. Overall, the net program costs are lowest under a taper rate of 60%, for a gain of 23% compared to the 2008 design.

Table 20 shows that the effects on tax revenue operate through the labor supply margin more than the formal-informal margin. The upper half of the

table describes life time labor supply, measured as the total number of years employed between ages 25 and 64. The changes are modest for most schooling and gender categories, of the order of 2-3months. A key exception is male college graduates: they work on average one extra year when moving from a 100% to a 30% taper rate. Male college graduates also account for most of the tax revenue, due to progressive taxation, which is why they drive the changes in total revenue observed in table 19. By contrast, the second part of the table shows that life time contribution densities are largely invariant to the minimum pension design.

7 Conclusion

The vast majority of research on pension design assumes that pension rules can be imposed on all workers. However, in most countries around the world, this not the case. This paper provides evidence that the informal sector is not merely a residual labor market, but rather offers workers competitive earnings opportunities. As a result, pension program participation becomes a choice, rather than an obligation.

We show that this additional economic margin is quantitatively relevant for pension system design. One of the justifications for mandatory pension contributions is that they help contain the costs of retirement income transfers. However we find that they can create a significant reduction in formality and tax revenue. In our simulations, a lower mandatory contribution rate actually reduces the net cost of the pension program.

We also look at the rate at which minimum pension benefits taper off as a

function of accumulated pensions savings. Lower taper rates impose a weaker implicit tax on pension contributions. However they increase the fraction of households who are eligible for a minimum pension, and who thus face such a tax. We find that highly tapered designs reduce costs conditional on a given minimum pension level. In particular a 60% taper rate is 23% cheaper than Chile's current 30% taper rate when both minimum pension outlays and tax revenue are considered.

The analysis in this paper could be extended in a number of meaningful ways. An important but challenging one would be to model household formation and dissolution. This would allow us to incorporate single, separated and widowed individuals in the estimation sample, all groups that are important targets of safety net policies.

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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.

Employment spells in salary jobs in which a contract was reportedly signed were coded as formal, while self-employed spells and salary jobs without a contract were classified as informal.[51] 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 formal jobs is Formal ($d_t^2 = 1$), and a respondent with a majority of informal jobs is Informal ($d_t^2 = 1$). The annual indicator was then

[51]For self-employed workers, contributions to the system are optional rather than mandatory. About one out of six self-employed workers is actually formal (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 informal.

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 full household 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.

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 formal 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 formal job (i.e., was at home or working in an informal 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 formal experience
% husbands choosing each of the three alternatives by 5-year tranches of informal experience
% wives choosing each of the three alternatives by 5-year tranches of formal experience
% wives choosing each of the three alternatives by 5-year tranches of informal 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 formal sector under age 35 by sex
% of years in formal 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

Table 1: Income tax brackets

Bracket minimum	0.0	4.9	10.9	18.2	25.5	32.7	43.6	54.6
Bracket maximum	4.9	10.9	18.2	25.5	32.7	43.6	54.6	-
Tax rate	0.0	0.05	0.10	0.15	0.25	0.32	0.37	0.40

Entries in million Chilean pesos (1 USD = 475 CLP as of 9/12/2011).

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

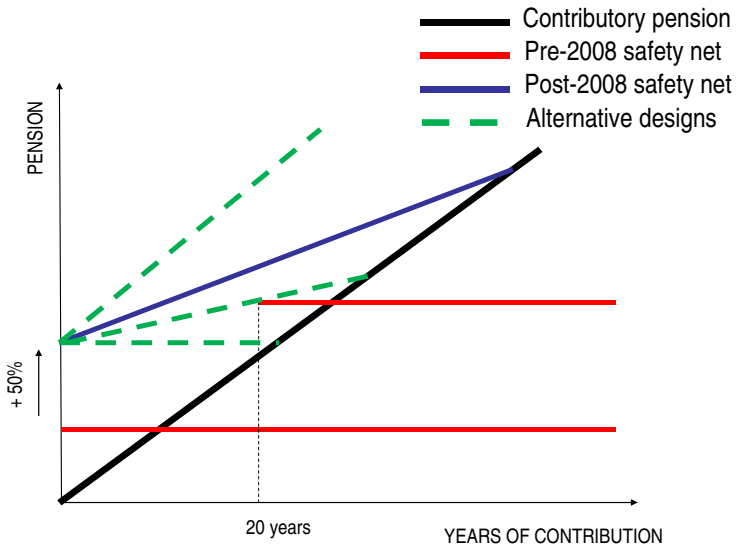

Table 2: Person-period observations by age group and birth cohort

	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 3: Summary statistics

Sample restrictions	**(1)**		**(2)**		**(3)**	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
Sector choice****						
% in the formal sector	66.9	28.5	66.6	28.4	64.0	40.4
% in the informal sector	26.0	19.3	26.2	19.3	27.7	21.7
% at home	7.1	52.2	7.1	52.3	8.3	37.9
% of high school grads						
Formal sector	55.5	70.7	56.6	70.0	61.6	74.3
Informal sector	39.7	46.2	40.3	44.3	44.3	52.2
Annual earnings†***						
median (Formal sector)	2.4	1.7	2.5	1.7	2.4	1.9
median (Informal sector)	1.8	0.9	1.8	0.9	1.4	1.0
Formal experience						
>75% of years worked	59.4	56.0	59.2	56.5	56.2	58.3
<25% of years worked	15.9	20.7	16.0	19.7	17.4	18.0
Pension savings†**						
median (ages 20-29)	0.2	0.0	0.2	0.0	0.1	0.0
median (ages 30-39)	1.3	0.1	1.3	0.1	0.2	0.0
median (ages 40-49)	3.3	0.1	3.3	0.1	0.2	0.0
Household assets†*						
median (ages 20-29)	1.2		1.2		4.7	
median (ages 30-39)	4.0		4.0		4.7	
median (ages 40-49)	5.9		6.0		5.8	

(1)Estimation sample,
(2)2006 EPS sample with age, cohort and civil status restrictions only,
(3)2006 EPS sample with age restrictions only.
*2004 and 2006 EPS cross-sections , **1980-2001 Administrative data panel, ***2002-2006 EPS earnings panel, ****2006 EPS cross-section, †Million Chilean pesos (1 USD = 475 CLP as of 9/12/2011).

Table 4: Fraction of employed workers making pension contributions 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 5: Household characteristics by unobserved heterogeneity type

Unobserved type	**1**	**2**	**3**
Fraction of sample (%)	40.6	57.6	1.7
Mean age in 2006	38.8	37.1	43.1
Men's schooling attainment:			
$<$ High School (%)	68.5	32.6	93.1
Women's schooling attainment:			
$<$ High School (%)	64.6	36.1	33.0
Simulated labor choice in 2006:			
Women Working (%)	25.5	51.6	91.7
Men in Formal Jobs† (%)	66.7	74.5	43.4
Women in Formal Jobs† (%)	63.2	71.0	6.0
Simulated savings in 2006 (MM. CLP):			
Non-pension savings	5.85	7.89	13.62
Men's pension savings	3.43	4.33	0.25
Women's pension savings	0.63	1.00	0.35
Fraction myopic (%)	3.7	0.5	3.2

†Conditional on being employed.
MM. CLP: Million Chilean pesos (1 USD = 475 CLP as of 9/12/2011).

Table 6: Model fit: Labor sector choice by age and schooling

	Husbands		Wives			Husbands		Wives	
	Data	**Model**	**Data**	**Model**		**Data**	**Model**	**Data**	**Model**
					Formal Sector				
					(% of the sample)				
Age					**Schooling**				
25	71.8	69.6	28.4	24.5	No H.S.	50.9	53.4	12.7	15.9
30	68.3	69.5	25.9	29.1	H.S. dropout	63.5	65.3	18.8	21.0
35	65.2	67.4	25.1	28.2	H.S. grad	75.5	74.1	32.9	31.4
40	60.9	66.3	24.0	23.1	Col. Grad	80.4	83.6	59.2	51.4
45	61.8	64.1	19.4	19.9					
					Informal Sector				
					(% of the sample)				
Age					**Schooling**				
25	25.2	26.6	9.9	15.0	No H.S.	42.7	38.6	11.3	8.8
30	28.5	27.9	11.2	13.7	H.S. dropout	32.9	30.5	14.8	14.2
35	30.6	29.2	15.0	14.4	H.S. grad	21.5	24.1	12.1	15.9
40	33.5	29.7	18.1	14.3	Col. Grad	14.4	16.0	14.5	21.1
45	31.1	30.5	20.2	17.0					
					Home production				
					(% of the sample)				
Age					**Schooling**				
25	3.1	3.8	61.7	60.5	No H.S.	6.4	8.1	76.0	75.3
30	3.3	2.6	62.9	57.1	H.S. dropout	3.6	4.1	66.4	64.8
35	4.3	3.5	59.9	57.5	H.S. grad	3.0	1.7	55.0	52.7
40	5.5	4.0	57.9	62.8	Col. Grad	5.1	0.5	26.4	27.5
45	7.2	5.4	60.3	63.1					

Table 7: Model fit: Conditional contribution densities*

	Men				Women			
	Age < 35		**Age > 35**		**Age< 35**		**Age> 35**	
	Data	**Model**	**Data**	**Model**	**Data**	**Model**	**Data**	**Model**
0-24%	20.1	21.1	19.2	19.2	24.6	36.6	21.0	32.8
25-49%	7.0	6.2	7.1	6.8	7.6	6.5	5.8	6.2
50-74%	12.7	11.1	10.9	13.0	8.5	9.5	8.5	7.5
75-100%	60.1	61.6	62.8	61.0	59.3	47.5	64.6	53.5

*Conditonal contribution density: fraction of years spent in formal jobs between the ages of 25 and 64 conditional on being employed.

Table 8: Model fit: Employment transitions

	Men		Women	
	Data	**Model**	**Data**	**Model**
Formal to...*				
Formal	94.6	94.0	85.9	95.6
Informal	4.4	5.2	3.1	0.8
Home	1.0	0.9	11.0	3.6
Informal to...*				
Formal	8.8	12.5	5.2	2.1
Informal	89.8	85.0	81.9	84.0
Home	1.4	2.4	12.9	13.9
Home to...*				
Formal	26.2	22.7	4.4	2.5
Informal	9.2	21.7	3.6	3.8
Home	64.6	55.5	92.0	93.8

*Fraction of workers in sector A at t+1 among those working in sector B at t.

Table 9: Model Fit: Household labor force participation

	Data	**Model**
Husband's/Wife's sector *(% of households in 2004 and 2006)*		
Formal/Formal	17.7	17.4
Formal/Informal	7.8	8.8
Formal/Home	39.8	42.7
Informal/Formal	6.2	8.8
Informal/Informal	5.2	4.1
Informal/Home	17.8	15.1
Home/Formal	1.4	1.6
Home/Informal	1.0	1.1
Home/Home	4.2	0.5

Table 10: Model Fit: Savings

	Non-pension savings		Pension savings			
			Husband		Wife	
	Data	**Model**	**Data**	**Model**	**Data**	**Model**
Distribution *(MM. CLP)*						
mean	7.00	6.67	2.14	1.86	0.49	0.39
sd	8.81	7.45	3.44	2.33	1.32	1.10
p10	-0.04	0.00	0.00	0.00	0.00	0.00
p50	4.72	5.15	0.98	1.11	0.02	0.00
p90	17.50	14.05	5.45	4.75	1.37	1.12
By Age *(Median in MM. CLP)*						
25	1.51	2.67	0.35	0.54	0.01	0.00
30	3.00	4.33	1.18	1.43	0.03	0.00
35	4.85	5.54	2.31	2.59	0.04	0.00
40	5.03	5.93	4.06	3.97	0.01	0.00
45	8.00	6.67	7.54	5.16	0.00	0.00
By Education *(Median in MM. CLP)*						
No HS	4.12	3.87	0.33	0.43	0.00	0.00
HS dropout	4.28	5.00	0.84	0.97	0.00	0.00
HS grad	4.96	5.58	1.40	1.48	0.05	0.00
College grad	8.10	6.35	2.10	2.33	0.18	0.00

MM. CLP: Million Chilean pesos (1 USD = 475 CLP as of 9/12/2011).

Table 11: Model Fit: Annual earnings

	Husband				Wife			
	Formal Sector		Informal Sector		Formal Sector		Informal Sector	
	Data	Model	Data	Model	Data	Model	Data	Model
Distribution *(MM. CLP)*								
mean	3.11	2.72	2.32	2.34	1.81	1.43	1.11	1.00
sd	2.29	1.82	2.22	1.96	1.25	1.06	1.04	0.93
p10	1.44	1.06	0.60	0.62	0.42	0.51	0.15	0.31
p50	2.40	2.28	1.80	1.82	1.56	1.14	0.80	0.72
p90	5.40	4.86	4.32	4.61	3.60	2.66	2.40	1.95
By Education *(Mean in MM. CLP)*								
No HS	1.76	1.42	1.35	1.11	0.97	0.81	0.66	0.43
HS dropout	2.22	2.12	2.19	1.92	1.24	1.10	0.95	0.75
HS grad	3.51	3.09	3.09	3.17	1.96	1.59	1.37	1.12
College grad	6.88	5.06	6.17	5.12	2.97	2.12	2.14	2.10

MM. CLP: Million Chilean pesos (1 USD = 475 CLP as of 9/12/2011).

Table 12: Parameter estimates - Preferences

Name	**Notation**	**Estimate** ***(Std. error)***
Discount rate		
Type 1	ρ^1	6.93E-02 *(3.97E-03)*
Type 2	ρ^2	6.76E-02 *(3.61E-03)*
Type 3	ρ^3	6.26E-02 *(4.03E-03)*
Fraction of myopic households		
Type 1	p_m^1	3.69E-02 *(1.37E-02)*
Type 2	p_m^2	4.67E-03 *(5.75E-03)*
Type 3	p_m^3	3.22E-02 *(8.44E-02)*
Elasticity of intertemporal substitution	σ	1.57E+00 *(3.24E-02)*
Non-pecuniary benefits		
Home		
Female - type 1	$\delta_3^{W,1}$	8.55E-02 *(1.09E-02)*
Female - type 2	$\delta_3^{W,2}$	4.41E-02 *(4.19E-03)*
Female - type 3	$\delta_3^{W,3}$	1.60E+00 *(6.74E-01)*
Male - type 1	$\delta_3^{H,1}$	9.50E-02 *(1.45E-02)*
Male - type 2	$\delta_3^{H,2}$	1.90E-02 *(5.98E-03)*
Male - type 3	$\delta_3^{H,3}$	3.06E-02 *(1.27E-02)*
Spouse complementarity	δ^C	7.20E-02 *(1.05E-02)*
Informal sector		
Female - type 1	$\delta_2^{W,1}$	1.24E-02 *(4.10E-03)*
Female - type 2	$\delta_2^{W,2}$	1.00E-03 *(6.27E-04)*
Female - type 3	$\delta_2^{W,3}$	3.19E-03 *(6.51E-03)*
Male - type 1	$\delta_2^{H,1}$	-2.34E-03 *(1.65E-03)*
Male - type 2	$\delta_2^{H,2}$	3.88E-06 *(1.62E-04)*
Male - type 3	$\delta_2^{H,3}$	-7.32E-04 *(2.02E-03)*
Cost of switching sectors		
Male	ϕ_s^H	3.11E-01 *(5.20E-02)*
Female	ϕ_s^W	6.14E-01 *(9.01E-02)*
Cost of returning to work		
Male	ϕ_a^H	8.41E-02 *(1.09E-02)*
Female	ϕ_a^W	2.77E-01 *(3.55E-02)*
Standard Dev. of Leisure shocks		
Male	σ_P^H	9.90E-04 *(1.22E-04)*
Female	σ_P^W	7.95E-04 *(8.42E-05)*

Table 13: Parameter estimates - Earnings offers

Name	**Notation**	**Estimate** ***(Std. error)*** **Men**	**Women**
Intercept - Formal sector			
Type 1	$\alpha_F^{i,1}$	-6.17E-01 *(3.55E-02)*	-1.36E+00 *(1.23E-01)*
Type 2	$\alpha_F^{i,2}$	-5.74E-01 *(5.37E-02)*	-1.37E+00 *(7.26E-02)*
Type 3	$\alpha_F^{i,3}$	-3.21E+00 *(4.25E-01)*	-2.70E+00 *(6.98E-01)*
Intercept - Informal sector			
Type 1	$\alpha_I^{i,1}$	-1.10E+00 *(5.76E-02)*	-2.04E+00 *(1.39E-01)*
Type 2	$\alpha_I^{i,2}$	-1.08E+00 *(7.08E-02)*	-1.80E+00 *(7.04E-02)*
Type 3	$\alpha_I^{i,3}$	-3.79E+00 *(4.08E-01)*	-1.19E+00 *(1.23E-01)*
Returns to education			
Formal sector	$\theta_{E,F}^i$	8.55E-02 *(3.45E-03)*	6.83E-02 *(5.83E-03)*
Informal sector	$\theta_{E,I}^i$	1.20E-01 *(4.57E-03)*	8.53E-02 *(6.26E-03)*
Returns to experience			
Formal experience	$\theta_{X,F}^i$†	1.99E-02 *(1.53E-03)*	4.50E-02 *(2.04E-03)*
Informal experience	$\theta_{X,I}^i$†	2.24E-02 *(1.69E-03)*	4.06E-02 *(2.73E-03)*
Interaction terms			
Exp.*school.	$\theta_{X,E}^i$†	8.73E-04 *(1.50E-04)*	1.25E-03 *(1.37E-04)*
Exp.*Col.grad.*Formal	$\theta_{X,F,E}^i$†	1.48E-02 *(2.22E-03)*	-6.36E-03 *(1.90E-03)*
Cohort effect	θ_{bc}	5.00E-02 *(4.62E-03)*	
Age	θ_a	1.84E-04 *(9.41E-05)*	
Age*Age	θ_{a2}	1.00E-04 *(2.49E-05)*	
Experience transferability	τ_{XP}^j	9.96E-01 *(1.30E-01)*	
Sd. of earnings shock			
Formal sector	σ_F^i	2.19E-01 *(1.51E-02)*	2.21E-01 *(2.99E-02)*
Informal sector	σ_I^i	3.20E-01 *(2.87E-02)*	1.90E-01 *(3.65E-02)*

†Returns to experience are allowed to depend on schooling in the following way:
$\theta_{X,j}^i(E) = \theta_{X,j}^i + E^i * \theta_{X,E}^i + I_{Formal,Col.grad.} * \theta_{X,F,E}^i$

Table 14: Parameter estimates - Probability of receiving a formal job offer

Name	**Notation**	**Estimate** ***(Std. error)***	
		Men	**Women**
Constant	γ^i	2.10E+00 *(4.98E-01)*	3.17E+00 *(6.35E-01)*
Schooling level	γ^i_E	1.00E+00 *(2.40E-01)*	8.27E-01 *(3.01E-01)*
Formal job at t-1	γ^i_F	4.95E-01 *(2.19E-01)*	4.84E-02 *(6.69E-02)*
Formal experience	γ^i_{XP}	-3.20E-02 *(1.64E-02)*	-1.25E-02 *(9.15E-03)*

Table 15: Parameter estimates - Type probability

Name	**Notation**	**Estimate** ***(Std. error)***	
		Type 2	**Type 3**
Constant	$\lambda(\psi)$	3.20E+00 *(3.24E-01)*	1.80E+00 *(2.19E-01)*
Schooling level (Husband)	$\lambda^H_E(\psi)$	-9.07E-01 *(9.59E-02)*	2.22E+00 *(5.50E-01)*
Schooling level (Wife)	$\lambda^W_E(\psi)$	-3.39E-01 *(9.93E-02)*	-2.11E+00 *(4.99E-01)*
Cohort	$\lambda^{bc}_E(\psi)$	-1.73E-01 *(4.91E-02)*	1.04E+00 *(2.39E-01)*

Table 16: Labor market segmentation analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Informal sector *(% of employment in 2006)*							
All Men	28.9	23.6	52.6	38.6	29.4	28.3	28.9
No H.S.	42.8	33.8	73.5	36.3	44.2	42.3	42.8
Some H.S.	32.3	26.5	56.0	37.9	32.6	31.7	32.3
H.S. grad.	24.5	20.4	44.4	43.3	24.9	24.0	24.5
Col. grad.	15.5	11.8	54.0	15.6	15.4	13.8	15.5
25-34	24.7	20.7	47.0	38.4	25.0	24.3	24.7
35-44	30.5	24.7	53.9	38.5	31.0	29.8	30.5
45-54	31.7	25.9	59.4	39.7	32.4	31.0	31.7
All Women	33.3	29.0	69.7	69.6	28.2	31.7	33.3
No H.S.	37.6	30.4	79.6	69.3	29.7	35.2	37.6
Some H.S.	38.1	33.3	78.8	68.5	31.7	36.6	38.1
H.S grad.	31.5	27.4	65.3	71.3	27.2	29.9	31.5
Col. grad.	24.9	22.7	53.9	64.0	21.7	24.0	24.9
25-34	27.9	24.0	66.5	63.8	23.2	27.0	27.9
35-44	34.2	29.7	70.9	71.6	28.7	32.3	34.2
45-54	43.1	38.1	72.3	79.9	38.2	40.6	43.1

Simulated counterfactual scenarios:
(1) Baseline (estimated model)
(2) Barriers to entry (probability of receiving a formal earnings offer set to 1)
(3) Returns to skills (returns to schooling and wage fixed-effects equalized across sectors)
(4) Returns to experience (returns to experience equalized across sectors)
(5) Non-pecuniary benefits (non-pecuniary benefits equalized across sectors)
(6) Taxes (formal sector not taxed)
(7) Pre-2008 safety net (no minimum pension guarantee)

Table 17: Impact of the mandatory pension contribution rate on informality

Contribution Rate	**0.05**	**0.75**	**0.1**	**0.125**	**0.15**	**0.175**	**0.2**
Informal sector *(% of employment in 2006)*							
All Men	27.4	28.0	28.9	30.7	32.5	34.4	36.2
No H.S.	41.0	42.0	42.8	44.5	46.6	49.2	50.7
Some H.S.	30.1	31.0	32.3	34.4	36.5	38.4	40.0
H.S. grad.	23.6	23.8	24.5	26.3	28.0	29.8	31.7
Col. grad.	14.5	14.5	15.5	16.0	17.4	19.2	21.2
Type 1	31.6	32.5	33.3	34.7	36.2	38.1	39.7
Type 2	24.0	24.4	25.5	27.7	29.7	31.7	33.6
Type 3	64.7	59.8	56.0	52.9	55.3	51.5	53.5
All Women	31.3	31.8	33.3	34.7	36.4	37.0	38.6
No H.S.	33.7	34.5	37.6	38.4	40.4	42.0	44.5
Some H.S.	34.9	36.0	38.1	41.2	44.0	45.6	47.4
H.S grad.	30.1	30.2	31.5	32.3	33.6	33.6	35.0
Col. grad.	23.3	24.9	24.9	25.6	26.4	27.3	29.5
Type 1	37.1	36.8	36.8	36.3	37.0	37.2	37.8
Type 2	26.2	27.0	28.9	30.9	32.9	33.7	35.8
Type 3	94.9	94.7	94.1	93.8	94.1	93.7	93.5
Uncond. contribution densities† *(% of workers at age 64)*							
Men							
0-24%	21.85	22.18	22.91	24.45	26.06	28.07	29.88
25-49%	14.44	13.65	13.96	14.41	14.88	15.26	15.50
50-74%	19.56	18.14	16.50	14.47	12.89	11.78	11.07
74-100%	44.15	46.03	46.62	46.67	46.17	44.88	43.55
Women							
0-24%	65.52	68.05	70.51	72.18	73.30	73.57	74.82
25-49%	13.79	11.34	9.59	8.50	7.65	7.43	6.62
50-74%	12.49	12.11	11.42	10.18	9.36	8.69	8.14
74-100%	8.21	8.49	8.48	9.14	9.69	10.30	10.42

†Unconditional contribution densities: fraction of years between age 25 and 64 spent in formal jobs (unconditional on being employed).

Table 18: Impact of the mandatory pension contribution rate on savings, earnings, consumption and program costs

Contribution Rate	**0.05**	**0.75**	**0.1**	**0.125**	**0.15**	**0.175**	**0.2**
Earnings *(MM.CLP, in 2006)*							
mean	3.82	3.79	3.82	3.80	3.78	3.78	3.76
Non-pension savings *(MM.CLP, in 2006)*							
mean	9.23	7.81	7.15	6.86	6.71	6.70	6.73
Pension savings *(MM.CLP, in 2006)*							
mean - Men	1.38	2.65	3.90	5.09	6.23	7.30	8.30
mean - Women	0.36	0.60	0.84	1.09	1.33	1.60	1.80
Consumption *(MM.CLP)*							
mean in 2006	3.24	3.27	3.24	3.19	3.11	3.05	2.99
mean lifetime std. dev.	1.80	1.87	1.93	2.04	2.16	2.26	2.34
No H.S.‡	1.09	1.09	1.11	1.17	1.23	1.28	1.33
Some H.S.‡	1.35	1.40	1.45	1.54	1.65	1.74	1.81
H.S grad.‡	1.97	2.04	2.12	2.27	2.42	2.55	2.66
Col. grad.‡	4.49	4.80	4.87	4.96	5.05	5.09	5.07
Pension program cost *(MM.CLP)*							
Program cost	0.45	0.16	0.09	0.07	0.06	0.06	0.05
Tax revenue†	0.14	0.09	0.00	-0.08	-0.14	-0.20	-0.26
Cost-tax revenue	0.31	0.07	0.09	0.14	0.20	0.26	0.31

MM. CLP: Million Chilean pesos (1 USD = 475 CLP as of 9/12/2011)
†Absolute change relative to the 10% baseline under the pre-2008 safety net (column 3).
‡ Schooling attainment of the husband.

Table 19: Impacts of counterfactual safety nets on program costs

	(1)	(2)	(3)	(4)
Pension program cost				
(MM. CLP per capita				
Program cost	0.12	0.13	0.17	0.25
Tax revenue†	0.00	0.03	0.04	0.02
Cost-tax revenue	0.12	0.10	0.13	0.23

MM. CLP: Million Chilean pesos (1 USD = 475 CLP as of 9/12/2011)
†Absolute change relative to policy experiment (1)
Simulated policy experiments:
(1) Taper rate is 100%, minimum pension is 75.000 CLP per month.
(2) Taper rate is 60%, minimum pension is 75.000 CLP per month.
(3) Taper rate is 30%, minimum pension is 75.000 CLP per month (2008 Reform).
(4) Taper rate is 0%, minimum pension is 75.000 CLP per month.

Table 20: Impacts of counterfactual safety nets on labor supply.

	(1)	(2)	(3)	(4)
Lifetime labor supply *(Years worked btw ages 25 and 64)*				
All Men	34.92	35.10	35.10	34.93
No H.S.	33.10	33.13	33.14	33.20
Some H.S.	35.27	35.36	35.34	35.23
H.S. grad.	35.18	35.40	35.37	35.12
Col. grad.	34.87	35.61	35.85	35.61
All Women	12.62	12.48	12.38	12.26
No H.S.	16.64	16.58	16.53	16.44
Some H.S.	13.66	13.52	13.41	13.28
H.S grad.	11.29	11.15	11.03	10.90
Col. grad.	8.08	7.94	7.88	7.80
Unconditional contribution densities† *(% of workers at age 64)*				
Men				
0-24%	23.09	23.23	23.30	23.27
25-49%	14.25	14.10	14.07	14.24
50-74%	17.32	15.94	15.68	16.45
75-100%	45.33	46.73	46.95	46.04
Women				
0-24%	72.65	73.36	73.75	73.89
25-49%	8.92	8.64	8.44	8.46
50-74%	11.29	10.62	10.48	10.70
75-100%	7.15	7.38	7.33	6.95

†Unconditional contribution densities: fraction of years between age 25 and 64 spent in formal jobs (unconditional on being employed).
Simulated policy experiments:
(1) Taper rate is 100%, minimum pension is 75.000 CLP per month.
(2) Taper rate is 60%, minimum pension is 75.000 CLP per month.
(3) Taper rate is 30%, minimum pension is 75.000 CLP per month (2008 Reform).
(4) Taper rate is 0%, minimum pension is 75.000 CLP per month.