How the Design of a Pension System Influences Old Age Poverty and Gender Equity: A Study of Chile's Private Retirement Accounts System

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Abstract

This paper develops and estimates a dynamic model of individual's and couples' labor supply and saving decisions to analyze the effects of a recent pension reform in Chile. Chile has one of the longest-running nationwide private retirements accounts systems in the world, operating since 1980, and its pension system served as a model for many other countries. In 2008, Chile undertook a major reform of the system, which introduced new features designed to reduce old-age poverty and to reduce gender gaps in pension accumulations and benefits. We estimate the model using data collected prior to the reform and assess the out-of-sample fit of the model using one year of post-reform data. After finding that the model fits many features of the data well, we use it to simulate the short and long term effects of the pension reform as well as alternative reform designs.

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1 Introduction

Many pay-as-you-go social security systems in the United States and Europe face impending insolvency as the number of pensioners per worker rises. The kinds of reforms being considered include, for example, increasing the required contribution per worker, raising the standard retirement age, or completely overhauling the pension system by transiting to a private accounts system. Chile has been at the forefront of pension reform, having switched to a private retirement accounts system in 1980. Many plans proposed in the U.S. and in Europe are similar to Chile's current pension system. They outline a system in which all workers are mandated to contribute part of their income to a pension account that is managed by a money manager, either a government owned company or a private firm. Under the proposed plans and also under the current Chilean system, the government serves as a last resort guarantor, supplementing pension income if pension accumulations are insufficient, either due to low income or unfavorable investment returns. The Chilean pension fund system is known as the *Administradoras de Fondos de Pensiones* or *AFP* system.[1]

A potential drawback of a private retirements-account based system in the absence of noncontributory pensions is that it can leave women particularly vulnerable to old-age poverty.[2] This is because women typically experience lower wages, interrupted careers, younger retirement ages and longer life spans. In 2008, Chile undertook a major reform of its pension system largely out of concerns about old age poverty and observed gender gaps in pension accumulations and pension receipt. This paper studies how the design of Chile's privatized pension system influences gender differences in retirement benefits. Incorporating more generous noncontributory pension benefits into the pension system design, as was done through the 2008 Chilean pension reform, is one way of increasing reducing old-age poverty and increasing relative pension benefit levels for women, but it can also reduce incentives for both men and women to work and to save.

This study develops and estimates a dynamic structural model to examine how pension

[1] Chile's system served as a model for pension reform in many other countries (dates of adoption in parentheses), including Peru (1993), Argentina (1994), Colombia (1994), Uruguay (1995), Bolivia (1996), Mexico (1997), El Salvador (1998), Costa Rica (2000), Czech Republic (1994), Hungary(1998), Poland (1999), Bulgaria (2000), Estonia (2002), and Kazakhstan (1998).

[2] Noncontributory pensions are pension benefits that are not a function of the amounts contributed by the individual during her career.

system design and how the 2008 pension reform influences labor supply, private savings, pension accumulations, and retirement behavior of women and men. In the model, households, which can be either singles or couples, make choices over their lifetime with regard to labor supply, private savings and retirement in an environment with uncertainty about future wages, asset returns on pension savings, fertility, future divorce or widowhood and own survival. With regard to labor supply, men and women choose not only whether to work but also whether to work in the formal (covered) sector where pension contributions are mandatory or in the informal (uncovered) sector. In addition, women choose whether to work part-time or full-time. The model is estimated on longitudinal microdata from the *Encuesta de Proteccion Social (EPS)* merged with administrative data on pension funds.[3]

We use the estimated model to study how labor supply and savings behavior changes with the introduction of the 2008 pension reform in comparison to behavior under the previous pension system rules and in comparison to alternative pension program designs. Specifically, we estimate the model parameters by the method of simulated moments using pre-reform data from the 2004 and 2006 EPS Surveys. We evaluate the fit of the model both within sample (using the estimated model to forecast behavior in 2004 and 2006) and out-of-sample. That is, the simulations for the year 2009 are compared to the actual 2009 post-reform data, which was not used in estimation, as a way of validating the model. After finding the model fits many features of the data well, we use the model to analyze the effects of the pension reform five years out, in 2014.[4]

We analyze how the 2008 pension reform affects old age poverty rates, men's and women's pension accumulations and labor supply behavior. Specifically, we examine changes in the following indicators: level (average and distribution) of women's and men's pensions upon retirement, contribution densities for men and women at different ages, the coverage rate (or fraction of employed workers who make contributions) of men and women at different ages, pension savings accumulation of men and women at different ages, the fraction of men and women participating in the labor force and in the covered sector at different ages, how working decisions vary with number of children, the ages of retirement, and private savings

[3]The longitudinal household survey data were collected by the Microdata Center of the University of Chile and the administrative data come from the *Superintendencia de Pensiones*.

[4]See below for more detailed description of the data sources.

levels (of couples or singles). First, these indicators are projected to year 2014 to analyze the medium-term (five year) impacts of the reform. Then we evaluate the long-term effects of the reform by simulating the youngest cohort in our sample throughout its life cycle. We compare lifetime individual outcomes as well as government outlays and tax revenue under the actual reform and alternative scenarios.

Short-term simulations indicate that the changes in the pension system design introduced with Chile's 2008 pension reform dramatically reduce old age poverty and improve pension saving and receipt levels for women, bridging a sizable part of the male-female pension benefit gap. These benefits come mainly from the large expansion in eligibility for a minimum pension guarantee, the so-called basic solidarity pension (*Pension Basica Solidaria*, or PBS) and from an increase in the generosity of the minimum pension benefit.[5] The work requirements for receiving the minimum pension benefit guarantee were decreased through the reform.

In line with the available post-reform data evidence, the short-term simulations also indicate some potentially negative behavioral responses to the reform in terms of lower labor force participation rates at older ages and lower rates of participation in the formal (covered) sector. In contrast, younger men and women show modest increases in these dimensions. Our long-term simulations indicate that the latter effect will dominate once individuals have time to adjust to the reform.

We also anticipate that the new system will be ten times as costly as the old system, owing to its much larger coverage and benefit levels. Attempts to make the reformed pension system more incentive-compatible by tapering-off non-contributory benefits with pension accumulation levels are not expected to improve formal sector participation and tax revenue significantly. In addition, this feature accounts for half of the total cost of the reform.

The paper proceeds as follows. Section two discussed related literature on modeling effects of social security and pension rules. Section three gives some background on the Chilean pension system and describes the features of the 2008 pension reform that we incorporate in our analysis. Section four describes the model and section five the estimation method. Section six summarizes the data used in estimation, Section seven provides evidence on within-sample and out-of-sample model fit, and Sections eight and nine present the key results on evaluating the effects of the pension reform in the short and long-run respectively.

[5]The Chilean pension system and the 2008 reform are described in detail in section three below

Section ten concludes.

2 Related literature

Fields and Mitchell (1984) and Mitchell and Fields (1984) were the first to study how the structure of earnings, social security, and pension benefits affect retirement behavior within a model that assumed that individuals make a one time retirement age decision at age 60, taking into account future expected earnings and retirement benefits. They found that wealthier individuals retire earlier, and those who expect to gain more by postponing retirement retire later. Subsequent research developed and implemented fully dynamic modeling approaches that incorporate uncertainty in decision-making over time. An early dynamic model by Gustman and Steinmeier (1986) showed how pension benefits affect the lifetime budget constraint and alter the price of leisure at different ages, thus influencing the choice of retirement age. Stock and Wise (1990) analyzed the effect of pension plan provisions on the retirement age and also emphasized the importance of modeling uncertainty in accurately capturing the option value embedded in the decision to retire. Their estimation was based on a retirement decision rule that was motivated by a dynamic programming rule, but was computationally less complex. Berkovec and Stern (1991) estimated the first dynamic discrete choice model of individual retirement decisions using a dynamic programming set-up. Subsequent papers additionally incorporated into the basic dynamic discrete choice modeling framework other aspects, such as health expenditure risk, savings and detailed institutional pension rules to provide a fuller accounting of retirement determinants.[6]

The more recent literature estimates dynamic structural models of the joint retirement decisions of husbands and wives. Our modeling framework is most closely related to that of Van der Klaauw and Wolpin (2008) who study how the design of U.S. social security rules affects decision-making within a collective model. As in their model, we allow households to accumulate private savings in addition to pension benefits for consumption in retirement. We focus on gender aspects of pension design, so we additionally incorporate into our model divorce and separation, which are major financial risks for women with low private and pension savings and low attachment to the labor force. We do not incorporate health or

[6]See, e.g., Rust and Phelan (1997), French (2005), Blau and Gilleskie (2008), French and Jones (2011)

health insurance and allow only women and not men to work part-time.[7] Another important difference is that our model allows workers to make a choice about being employed in the informal sector, in which they do not accumulate pension rights, which is a crucial margin from a public finance point of view in Chile and in many other Latin American countries.

Other recent collective models of joint retirement include Blau and Gilleskie (2006), who focus on retirement incentives related to spousal health benefits, and Casanova (2011), who investigates the timing of retirement between two married individuals. Because these papers are not concerned with the difference in financial risk borne by each spouse individually, they model divorce and death through a terminal value, instead of following, as we do, the individuals after separation or death has dissolved the household.[8] Many individuals, and women in particular, spend a significant part of their retirement as widows, so following them after their spouse dies is important to understanding the sources of old age poverty.

This paper also builds on a previous study by Joubert (2012) of the relationship between pension design and labor force participation decisions with regard to informal/formal sector work using the same Chilean data that we use. This study extends Joubert (2012) by using a collective model of the household with distinct male and female utility functions, and by allowing for divorce and fertility, which make the model suitable for studying the differential impact of the 2008 pension reform on men and women.

As previously noted, this paper analyzes how pension system design and the 2008 Chilean pension reform influences labor supply, savings and retirement decisions. Thus far, there have only been a few studies examining short term effects of the 2008 Chilean pension reform. Behrman, Calderon, Mitchell, Vasquez, and Bravo (2011)analyze the effects of the PBS (the Basic Solidary Pension), which was one feature of the pension reform, on household income as well as on outcomes related to household work, health status, expenditures on alcohol and cigarettes, health insurance and ownership of consumer durables.[9] They use a difference-in-difference approach to compare the change in income/outcomes over time for treated families that qualify for the PBS (by virtue of being poor and having a family member age 65+)

[7]Part-time work is relatively rare for men in Chile: less than 8% of men worked part-time (weekly hours below 30) in 2004.

[8]Other notable papers are Gustman and Steinmeier (2000, 2002) who consider a non-cooperative game solution to the household joint decision, and Gallipoli and Turner (2011) who compare non-cooperative and collective models of joint retirement.

[9]All the features of the reform are described in the next section.

and households that are poor but otherwise do not qualify. The pre-treatment year is 2006, two years before the reform, and the post-treatment year is 2009, one year after the reform. Behrman et. al. (2011) find that PBS eligible households had 2.4% more in household annual income relative to non-targeted households, with little evidence of crowding out of private transfers. In addition, targeted households report higher expenditures on health care, more leisure hours and have improved self-reported health. The Behrman et. al. (2011) analysis does not provide a framework for doing long-term program impact predictions nor for studying the effects of hypothetical pension programs that differ significantly from the one actually implemented. Although the estimated effects the study finds are modest and statistically significantly different from zero only for a few of the outcomes analyzed, they are generally positive.[10]

Another recent study by Attanasio, Meghir and Otero (2011) examines the effects of Chile's pension reform on formal and informal labor market participation. Following an approach previously used by Attanasio and Rodwedder (2003) and Attasio and Brugiavini (2003), the study uses changes in expected pension wealth and pensions across groups and time to estimate the relationship between pension wealth and savings rates. As Attanasio et. al. (2011) note, however, "One important difficulty in calculating pension wealth is that future labor supply will change as well as current one, as a result of the reform. In order to capture the relationship completely, a fully specified dynamic model should be used." Using forecast equations to forecast wages and labor supply for periods when they are not observed, Attanasio et. al. (2011) find that the welfare component of the reform increased self-financed pension wealth by only 0.6% but increased final pension levels by 15%. They also find that the increase in pension wealth upon retirement reduced slightly the rate of participation in formal sector jobs, by around 4.1% for workers older than age 40.

[10] An implicit assumption of Behrman et. al.'s (2011) difference-in-difference approach is that households who do not qualify for the program at a point in time do not anticipate that they may qualify at some future time period, which could affect their current behavior even if they are not actively receiving benefits. The dynamic structural modeling framework used in this study explicitly incorporates such possible anticipatory effects.

3 Background on the Chilean pension system and the 2008 reform

When it was introduced in 1980, the privatized Chilean pension system, called the AFP system, replaced a heterogeneous pay-as-you-go system composed of many different institutions (called *Cajas de Prevision*) that covered different professions and subsets of the population.[11] Individuals in the old pension system (called the INP system) had the option of transferring to the new AFP system based on individual capitalization or to remain in the old system.[12] 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.[13] By the end of 1983, 77% of workers from the old system had switched to the new one (Acuña and Iglesias (2001)).

The 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 pay a 10% contribution of their monthly wages (up to a cap) into a tax-deferred pension account, which is for the most part inaccessible until retirement.[14]. A pension system affiliate can choose to invest his/her pension funds in one of a number of pension fund administrators (the AFP firms) who manage and invest the savings in the financial markets.

Individuals can access their pension savings at age 65 for men and 60 for women, with 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. The law also allows for early retirement, provided that the worker has pension funds sufficient to generate a pension amount equal to

[11] AFP =*Administradoras de Fondos de Pensiones*

[12] INP= *Instituto de Normalizacion Previsional*

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

[14] The restrictions on fund withdrawal are more stringent in Chile than they are for US 401K plans. The contributions are capped at 66 Unidades de Fomento, a monetary unit that is indexed to inflation. The value of the UF as of December 2004 was $17,317 pesos (US$31)In addition, workers must pay a contribution of 7% for health services, 0.8% for a disability and survivorship insurance, and an average of 2.6% to the pension fund manager as a commission or fee.

or greater than 110% of the minimum pension guaranteed by the State.[15]

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 a little less than a third of the minimum wags 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 benefit 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] Only 37% of women were projected to have a pension above the MPG level, in comparison with 67% for men, in part because few women are expected to reach the 20 years of contributions necessary to qualify for the MPG. The average projected replacement rate for women under the pre-reform pension system was 28% of the last wage in comparison to 51% for men.

An analysis of employment histories indicates that an important factor underlying gender gaps in projected pensions is that labor force participation is lower and more sporadic among women. Arenas de Mesa and Montecinos (1999) note that the direct link between lifetime earnings and pensions in the AFP system largely accounts for the lower average pensions for women, who tend to retire at earlier ages, participate less often in the labor-force and earn lower salaries. A statistic that is sometimes used as a measure of pension program

[15]The pension must also be equal to or greater than 50% of the average taxable income for the last 10 working years

[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.

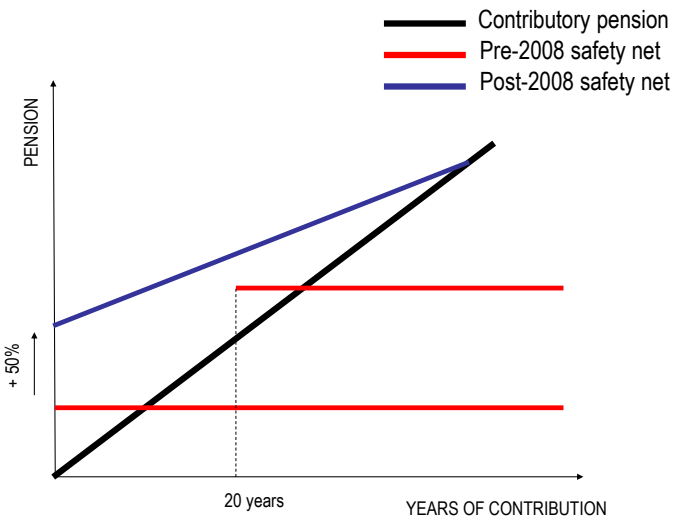

Figure 1: Pension benefit levels pre- and post- reform

participation is the *density of contributions*, which is the number of years the individual makes pension contributions divided by the number of potential working-age years. The density of contribution for women is 41% in comparison with 61% for men. Additionally, lower wages, earlier retirement ages and projected longer life spans, which affect annuity pay-outs, all serve to reduce the level of women's pensions relative to men's.

Reducing the gender gap in pension benefits/accumulations was a significant objective of the 2008 pension reform. The reform replaced the PASIS pension and the minimum pension guarantee (MPG) with a so-called "New Solidarity Pillar" that augments pension levels of workers with relatively few years of contributions. The new safety net implements a means-tested welfare pension, which will eventually guarantee 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. In addition to providing a minimum pension level, the new system augments low contributory pensions through the

[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 is expected to reach 60% in July 2011 and eligibility will be based on the household's income from September 2009 onwards.

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]

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

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 $75,000 - (100,000 * 0.3) = 45,000$. His/her total pension will then be 145,000 pesos per month.[21] James et al. (2003) note that the new state-financed minimum pension benefits that are targeted toward low earners often benefit women.

Figure 1 graphically shows the effect of the pension reform on the pension level that people qualify for as a function of their years of contribution. The two vertical lines show the PASIS pension benefit and also the minimum pension guarantee available to those with 20 yeas of contributions under the pre-reform system. The diagonal lines that intersect with (0,0) show the accumulated pension based on contributions for a high and a low earner. The two diagonal lines that intersect with the y axis represent the pension amounts under the reformed system and how the supplement gets reduced with additional contributory savings.

A second important feature of the 2008 pension reform with regard to gender equity is the introduction of a pension subsidy for mothers that depends on their number of children. This subsidy seeks to compensate for interruptions in contribution histories due to pregnancy and infant care. The subsidy level retroactively accounts for children born before the reform. When the woman turns 65, the state augments her pension savings with a benefit equal to a year and a half of pension contributions at the minimum wage (about 280,000 pesos in 2008), plus interests accrued since the birth of the child, minus commissions paid to the pension fund administrator. A third feature of the pension reform is a change in the rules

[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

[21] Before the reform, eligible workers effectively faced an implicit marginal tax rate of 100% on contributions over some range, in that additional contributions would not increase the level of pension upon retirement. The new system ensures that an additional contribution always increase the level of the retirement pension, and it maintains a constant implicit marginal tax rate of about 37% on additional contributions.

for dividing pension balances in the case of divorce or annulment. Before the reform, an individual would lose access to their spouse's pension upon divorce.[22] A judge can now rule that up to 50% of one of the spouse's pension balance be transferred to the other spouse's account after a divorce or annulment as a form of alimony. A fourth feature is a change in the premium for disability and survivorship benefits. Prior to 2008, women and men both paid about 1% of their wages towards disability and survivorship benefits, which is actuarially unfair to women. As of July 2009, men and women pay contributions that correspond to men's premium, but the difference in premiums is added back to a woman's pension account. Lastly, the pension reform also made it possible for someone who is not working (for example a stay-at-home mother) to make pension contributions. The contributions can be deducted from the taxable income of a third party, such as a spouse, who can contribute towards the voluntary affiliate's account.

Our evaluation of the effects of the 2008 pension reform focuses on the features that are most likely to produce large impacts on the disparity in pension levels between men and women. We introduce the following key features of the reform into the model:

(i) *The New Solidarity Pillar.* The NSP is most beneficial to workers with low pension savings accumulations who otherwise would not have contributed long enough to qualify for the MPG under the old system. The NSP is expected to disproportionately benefit women.
(ii) *The per-child bonus.* The child bonus is provided only to women, regardless of whether they actually experience career interruptions upon giving birth. The bonus could have some disincentive effects on women's labor supply either through a wealth effect (the benefit increases pension savings, so the household doesn't need to work and save as much) or by encouraging greater fertility, which in turn might lead to more career interruptions.
(iii) *Change in rules for divorce.* Wives can receive up to 50% of the husband's pension savings upon divorce.

Two aspects of the reform cannot be evaluated given our methodology. The first is the change in the premium paid by women per the Survivorship and Disability insurance, since the model does not incorporate health status, other than death. The second is the ability to make voluntary pension contributions. Under the current system, the percentage of the

[22]However, divorce only became legal in Chile in 2004.

population making voluntary contributions to their pension account above the mandated 10% level is very small: fewer than 2% of the system's affiliates had positive balances in their voluntary contributions account in 2005 (own calculations). Given the additional complexity required and given the relative infrequency of voluntary contributions in the data, we did not incorporate this aspect into the model. The model does incorporate decisions about private savings, but not the decision of whether to place the private savings into a tax-deferred pension account.

4 The Model

The dynamic behavioral model that we develop and estimate describes how households make decisions over their lifetime with regard to work and savings. It is important to recognize the existence of permanent unobservable sources of heterogeneity affecting decision-making, so the model incorporates unobserved discrete types.(See, e.g, Heckman and Singer (1984) and Keane and Wolpin (1997)).[23] A household may consist of either a couple or a single individual. In each period, couples face an exogenous probability of separation (described in detail below) or of one member of the couple dying, in which case the couples' problem changes to that of a single-headed household.

4.1 Timing and Initial conditions

The superscript $j \in \{m, f\}$ denotes gender, and the superscript 2 denotes a couple.[24] Periods in the singles' problem are indexed by the individual's age ($t = a_t^j$), while the couples' problem is indexed by the age of the female ($t = a_t^f$). For singles, the decision problem begins at ages $t_0^m = t_0^f = 35$.[25] For couples, the decision problem begins when the wife turns t_0^f. Thus, the age of the husband in the first period, $a_{t_0}^m$ is part of the initial conditions. Any household assets (A_{t_0}), work experience ($X_{t_0}^m, X_{t_0}^f$) accumulated prior to the first model period, as well as any children born prior to female age 35 (N_{t_0}) are also taken as initial

[23] In the empirical work, we incorporate two unobserved types. The number of types we could allow was limited due to the computational complexity of the model.

[24] We use the terms husband and wife, but the model could apply to non-married couples

[25] Singles at age 35 are assumed to remain single. Married couples are able to transition to being divorced or widowed, as further described below. We estimate the model for singles on people who remain single after age t_0^j.

conditions. The initial conditions also include pension savings $(B^m_{t_0}, B^f_{t_0})$, any pension rights accumulated by the two spouses under the earlier INP retirement system prior to age $a^j_{t_0}$ ("Bonos de reconocimiento") or under the new AFP system. Finally, the initial conditions include two permanent characteristics: completed schooling levels of men and women (e^j), and birth cohorts (bc^j).

We denote the set of initial conditions for a couple by $\Omega^2_{t_0}$ and for a single household by $\Omega^j_{t_0}$:

$$\Omega^2_{t_0} = \{a^m_{t_0}, A_{t_0}, B^m_{t_0}, B^f_{t_0}, X^m_{t_0}, X^f_{t_0}, N_{t_0}; e^m, e^f, bc^m, bc^f\}$$

$$\Omega^j_{t_0} = \{A^j_{t_0}, B^j_{t_0}, X^j_{t_0}, N_{t_0}; e^j, bc^j\}$$

Define an indicator variable for the unobserved type, $\mu_k = 1(\text{type} = k)$.

4.2 Decisions

In each period of the model, a two-person household makes a saving decision for the household (s_t), a labor force participation decision for each individual (d^m_t, d^f_t) and a part-time work decision for the woman (p^f_t), until age $t_R = 70$. The income that is not saved is split evenly into the two spouses' consumptions c^m_t, c^f_t. s_t is the fraction of income that is saved and not consumed in period t. The three employment options available to both men and women are to work in the covered sector $(d^j_t = 1)$, to work in the uncovered sector $(d^j_t = 2)$, or to stay home $(d^j_t = 3)$ for $j \in \{m, f\}$. In addition, female workers can chose to work part-time $(p^j_t = 1)$ or full-time $(p^j_t = 0)$.[26]

A one-person household makes the same savings and work decisions relevant to his/her gender, but consumes the full amount of income minus savings.

4.3 Preferences

Individuals derive utility from consumption and from leisure, if not working or working part-time. The utility of leisure is allowed to depend on unobserved type, k. The per period

[26]Part-time work (p_t) is only an option for females.[27] It is assumed that individuals cannot work after age $t_R = 70$.[28] Once spouse j reaches age t_R (age 70), the only option is leisure $(d^j_t = 3)$ for the remaining periods. Both single and married households make savings, labor participation and labor force sector (formal or informal) decisions.

utility function of a couple is the weighted sum of the utility of a single male and the utility of a single female, where the weights represent bargaining power (the weight is set to 0.5 in the simulations reported below):

$$U(c_t^m, c_t^f, d_t^m, d_t^f, p_t^f, N_t\epsilon_t^m, \epsilon_t^f; type = k) =$$
$$\theta u^m(c_t^m, d_t^m, N_t, \mu_k, \epsilon_t^m; type = k) + (1-\theta)u^f(c_t^f, d_t^f, p_t^f, N_t, \epsilon_t^f; type = k).$$

The terms $u^m(c_t^m, d_t^m, N_t, \epsilon_t^m; type = k)$ and $u^f(c_t^f, d_t^f, p_t^f, N_t, \epsilon_t^f; type = k)$ represent the utility from consumption, leisure, and number of children for a single household formed by a male and a female respectively. Part-time work (p_t) is only an option for females. The leisure preference shocks are assumed to be jointly distributed normally and to be uncorrelated over time:

$$(\epsilon_t^m, \epsilon_t^f) \sim iidN(0, \Sigma)$$

The period utility function is specified as:

$$u^j(c_t^j, d_t^j, p_t^j, N_t, \epsilon_t^j; type = k) =$$
$$\left(\tfrac{c_t^j}{1-\sigma}\right)^{1-\sigma}(1 + \exp\{\nu_0^j N_t + \nu_1^j d_{3,t}^j\}) +$$
$$(d_{3,t}^j + \delta_p^j p_t^j)(\delta_{lk}^j + \delta_n^j N_t + \delta_m^j m_t + \epsilon_t^j) +$$
$$\phi_{2k}^j d_{2,t}^j + \phi_s^j(d_{1,t}^j d_{2,t-1}^j + d_{2,t}^j d_{1,t-1}^j) + \phi_r^j(d_{1,t}^j d_{3,t-1}^j + d_{2,t}^j d_{3,t-1}^j)$$

This formulation allows the marginal utility of consumption to depend on the number of children and on labor market participation. The utility from not being employed is stochastic, type-specific and depends on the number of children (N_t) and marital status (m_t). δ_p^j captures the fraction of the utility of leisure received if employed part-time (an option only for women). Non-pecuniary benefits (or penalties) associated with the informal sector are captured by $\phi_{2,k}^j$, and the costs of switching sectors and entering the labor force are denoted as ϕ_s^j and ϕ_r^j respectively.

4.4 Household Income

The labor market consists of two sectors, a covered sector where pension contributions are mandatory, and an uncovered sector. Each working age individual (whether part of a couple

or single) receives an earnings offer from the uncovered sector in every period with probability one. In addition, with a probability Γ_t^j, individuals may receive an offer from the covered sector. The probability depends on his/her gender, level of schooling, age, and whether employed in the covered sector in the previous period.

$$\forall j \in \{m, f\}, t \in \{t_0, t_R\},$$
$$\Gamma_t^j = (1 + exp\{-(\gamma_0^j + \gamma_1^j I_{\{d_{t-1}^j=1\}} + \gamma_2^j e^j + \gamma_3^j X_t^j)\})^{-1}$$

The log-earnings offers (for males and females $j \in \{m, f\}$, in sector $s \in \{C, U\}$ of type $k = 1..K$ and with completed schooling levels e^j) are:

$$w_{s,t,k}^j = \sum_{k=1}^{K} \theta_{0sk}^j + \theta_{1s}^j \cdot e^j + \theta_{2s}^j \cdot X_t^j + \theta_{3s}^j \cdot (X_t^j)^2 + \epsilon_{s,t}^j$$

where $\theta_{0,s}^j$ is a gender- and sector-specific constant, θ_{1es}^j a gender-, sector-, schooling-specific cohort effect, θ_{2s}^j the sector-specific returns to schooling, and θ_{3es}^j and θ_{4es}^j the sector- and schooling-specific returns to experience. $\epsilon_{s,t}^j$ ($j \in \{m, w\}, s \in \{C, U\}$) are i.i.d. sector-specific earnings offer shocks that are uncorrelated across time-periods but potentially correlated between two members of the same household. The earnings offer specification allows returns to experience to differ in both sectors.

The total household disposable labor income y_t^2 is the sum of accepted earnings offers, net of income taxes and mandatory pension contributions:

$$y_t^2 = \sum_{i \in \{H,W\}} \frac{(1-\tau) \cdot w_{C,t}^i \cdot I_{\{d_t^i=1\}} + w_{U,t}^i \cdot I_{\{d_t^i=2\}}}{I(i=H) + I(i=W)(1+p_t^f)} - T(A_t, w_{C,t}^m, w_{C,t}^f, d_t^m, d_t^f, p_t^f)$$

where τ is the pension contribution rate (10%) and $I(.)$ denotes an indicator function. Household income for a single household, y_t^j, is defined similarly.

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 $T(A_t, w_{C,t}^m, w_{C,t}^f, d_t^m, d_t^f)$, and depend on the household's stock of private savings, covered sector earnings offers and labor force participation decisions. Net borrowing and borrowing against pension savings are not allowed. It is assumed that individuals working in the uncovered sector do not pay taxes on their labor income.

4.5 Separation and mortality

In each period, there is a probability of the man or woman (whether in a couple or single) dying, which is assumed to be exogenous with respect to the other aspects of the model.[29] Denote the probability of surviving to the next period as $\pi^{sj} = \pi^{sj}(a_t)$ for $j \in \{m, f\}$. Our model assume that widows inherit their former spouses pension funds.

Household separation (for reasons other than widowhood) is modeled as an exogenous event. Conditional on both spouses surviving, the probability of becoming separated in period t is assumed to depend on the man and woman's level of education (e^m, e^f), their ages $(a_t^m, a_t^f = t)$, and the number of children (N_t). Until 2004, divorce did not exist in Chile. For simplicity we treat divorce, marriage annulment and de facto separation as equivalent in the model. The separation probability is specified as a logistic model,

$\pi_t^d = \pi^d(e^m, e^f, N_t, a_t^m, t)$.

Upon separation, a couple's non-pension assets A_t are split evenly between the two individuals who then become single households.

Recall that one feature of the pension reform was a change in the rules governing pensions upon divorce. Prior to the reform, divorce could lead to a loss of rights to a spouse's pension benefits. After the reform, in the event of a divorce or annulment, a judge can rule that up to 50% of one of the spouse's pension balance be transferred to the other spouse's account as a form of alimony. In our model, we assume that before the reform, divorced individuals only have access to their own pension funds and do not get to keep their former spouse's pension. After the reform, the spouse that is followed in the data gets the maximum of either their own pension or one-half of the pooled pension savings of the wife and husband. To reduce computational complexity and because separation in old age is relatively rare, we assume that no separation occurs after the woman turns age 60 ($t = t_s$).

4.6 Retirement

At ages $t_C^f = 60$ and $t_C^m = 65$ years old respectively, males and females are allowed to withdraw money from their pension savings accounts. For tractability, we did not incorporate the choice about whether to take retirement savings as an annuity or as a phased withdrawal.

[29] We obtain these probabilities from life tables that are specific to Chile and are conditional on age and gender (RV-2004, from Circular 1314, published by the Superintendencia de Pensiones).

Rather, we assume phased withdrawal, because the formula is a simple function of age. The level of pension benefits is calculated according to the rules of the pension system in place, including the minimum pension guaranty (MPG) in the years when applicable. After age 65, either spouse may receive the pension benefits (PASIS, PBS, APS) for which they qualify, given their individual and family incomes, and according to the rules to which they are subject at that time (pre-reform until 2008, phased implementation of the reform from 2009 to 2011, post-reform after 2011).

By age t_R=70, it is assumed that individuals stop working, at which point they take leisure ($d_t^j = 3$) for all remaining periods. The last period of the model is age $t_D = 90$. When both spouses turn 70 and no longer have the option of working, the model assumes that households run down their accumulated savings by optimally consuming until they die or reach the last period (age 90). We assume that bequests (savings left after death of both spouses) are involuntary and do not generate utility.

4.7 Fertility

The number of children N_t is assumed to evolve stochastically. The probability of having another child is modeled as a logistic model, that depends on the woman's age, marital status, schooling level and and number of children in the previous period.

$$\pi^N j_t(N_t|N_{t-1}, a_t^j, e^f, marital\ status)$$

There are assumed to be no births after the woman turns age 40 (t=t_C).[30]

4.8 Evolution of other state variables

The model's other time-varying state variables, A_t, B_t^m, B_t^f, X_t^m, X_t^f are determined by the saving, labor supply decisions and asset return shocks. Private savings are assumed to earn the risk-free rate r, assumed to be 5%. 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: $r_B \sim iidN(\bar{r_B}, \sigma_B^2)$.[31]

[30]This assumption is made in part to reduce computational complexity.

[31]Individual returns will differ in part 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.

4.9 Recursive formulation of the Household's Problem

The optimization problem faced by a single individual of gender j has the following recursive formulation:

$$V_t^j(\Omega_t^j; \tilde{\epsilon}_t^j; type) =$$
$$\max_{s_t, d_t^j, p_t^j} \left[u^j(c_t^j, d_t^j, p_t^j, N_t, \epsilon_t^j; type) + \beta \pi^{sj}(t) EV_{t+1}^j(\Omega_{t+1}^j; \tilde{\epsilon}_{t+1}^j; type) \right]$$

s.t.

$$\begin{aligned} c_t^j &= (1 - s_t) \cdot (y_t^j + A_t \cdot (1 + r)) \\ A_{t+1} &= s_t \cdot (y_t^j + A_t \cdot (1 + r)) \\ A_{t+1} &\geq 0 \\ B_{t+1}^j &= B_t^j \cdot (1 + r_B) + \tau \cdot \frac{w_{C,t}^j}{1 + p_t^j} \cdot I_{\{d_t^j = 1\}} \end{aligned}$$

where $\tau \cdot w_{C,t}^j \cdot I_{\{d_t^j=1\}}$ is the pension contribution made by workers in the covered sector. y_t^j is the household's income defined earlier, and $\tilde{\epsilon}_t^j$ is a vector of shocks to wage offers, preferences for leisure, and pension asset returns. In addition to the constraints above that describe the evolution of pension and non-pension assets, the model includes the wage offer equations and the income/tax equation specified earlier. [32]

For couples, the continuation value imbeds five possible events:

- Both spouses die (the continuation value is 0 in this case)
- The husband dies and the maximization problem continues with the wife
- The wife dies and the maximization problem continues with the husband
- Both spouses survive and remain together
- Both spouses survive and separate and the problem continues with the sampled individual (either male or female)

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.

[32] Non-pension assets are assumed to earn a fixed rate of return of 5%.

Incorporating greater detail about the different possible next period options, the recursive formulation of the couple's problem can be written as:

$$
\begin{aligned}
V_t^2(\Omega_t^2;\tilde{\epsilon}_t^2) = \max_{s_t,d_t^m,d_t^f,p_t^m,p_t^f} & \Bigg[\\
U(c_t^m,c_t^f,d_t^m,d_t^f,p_t^m,p_t^f,N_t,\epsilon_t^m,\epsilon_t^f) & + \beta\cdot\Big(\\
& \quad \pi^{sf}(1-\pi^{sm})\cdot(1-\theta)EV_t^f(\Omega_{t+1}^f;\tilde{\epsilon}_{t+1}^2) \\
& + \pi^{sm}(1-\pi^{sf})\cdot\theta EV_t^m(\Omega_{t+1}^m;\tilde{\epsilon}_{t+1}^2) \\
& + \pi^{sm}\pi^{sf}(1-\pi^d)\cdot EV_{t+1}^2(\Omega_t^2;\tilde{\epsilon}_{t+1}^2) \\
& + \pi^{sm}\pi^{sf}\pi^d\cdot\Big[\theta EV_{t+1}^m(\Omega_{t+1}^m;\tilde{\epsilon}_{t+1}^2)+(1-\theta)EV_t^f(\Omega_{t+1}^f;\tilde{\epsilon}_{t+1}^2)\Big]\Big) \\
& \Bigg]
\end{aligned}
$$

s.t.

$$
\begin{aligned}
c_t &= (1-s_t)\cdot(y_t^2+A_t\cdot(1+r)-\eta N_t) \\
A_{t+1} &= s_t\cdot(y_t^2+A_t\cdot(1+r)-\eta N_t) \\
A_{t+1} &\geq 0 \\
B_{t+1}^j &= B_t^j\cdot(1+r_B)+\tau\cdot w_{C,t}^j\cdot I_{\{d_t^j=1\}}
\end{aligned}
$$

The variables on which the separation and divorce probabilities (pi^d) depend were omitted above to ease notation.

4.10 Discussion of the Model

4.10.1 Incorporating the 2008 pension reform

The model is dynamic and explicitly incorporates forward-looking behavior under a rational expectations assumption. It also incorporates uncertainty and incomplete information. Specifically, individuals are uncertain about future wage shocks, future fertility, future divorce or widowhood, future survival and investment returns at the time of making labor supply and savings decisions. In solving the model, we assume that the 2008 pension reform came as a surprise and was not anticipated. We assume this, in part, because our discussions

with the Budget Office in Chile indicated that the reform was not anticipated.[33] Thus, decisions up until 2008 are governed by a pre-reform decision model and decisions after 2009 are governed by a post-reform model. This requires solving two different versions of the model. The structural model parameters are estimated solely on pre pension reform data and then, fixing the parameters, the model is then resolved under the post-reform scenario.

The effects of the 2008 pension reform on decision-making and on the indicators described in section two can be assessed by simulating household behavior using the pre-reform pension model and then simulating the same households under the post-reform rules. For purposes of this simulation, we use as a starting point the initial conditions in the year 2004 and the simulate choices in years 2005-2014. Our tables report values in 2014, but of course pension values in 2014 reflect the choices made in prior years. A comparison of the choices and outcomes under the pre-reform and post-reform regimes is informative about the impact of the reform.

To a limited extent, the model incorporates business cycle effects in that returns on pension investments vary over time. Two limitations of the model are that investment returns are assumed to be i.i.d. and that there are otherwise no aggregate earnings shocks. However, aggregate demographic changes in the economy are incorporated in a few ways. First, the initial conditions include the education levels of the husband and wife and rising levels of education with successive birth cohorts will lead to different decision-making with regard to labor force participation and fertility. We expect, for example, that more recent cohorts of women who have higher education levels on average will tend to have fewer children and will participate more in the labor force. Also, the model takes marital sorting patterns as a given initial condition, so changes in marital sorting that may have occurred over time are also taken into account and can generate differences in behaviors across birth cohorts.

4.10.2 Incorporating labor market regulations

The model also incorporates some important labor market regulations. For example, the progressive tax structure is taken into account in computing after-tax income. Fees that workers pay for health and disability insurance are also taken into account. Lastly, the

[33]Modeling the reform as anticipated would have also been feasible, but would require somewhat arbitrary assumptions about when the details of the reform became known to workers.

model incorporates the fact that informal sector workers typically do not pay these taxes and fees.[34]

5 Solution and Estimation Method

5.1 Solution Method

The model does not have an analytic solution and is therefore solved numerically by backwards recursion. Model solution proceeds as follows. At age t_D-1, a household decides on labor force participation and consumption, which together imply a level of savings, to maximize the weighted sum of current and future period utilities, denoted by $V_{t_D-1}(\overline{S_{t_D-1}}, \{\epsilon^i_{j,t_D-1}\})$, where the state space, S_{t_D-1} , is divided into a deterministic component containing the elements that are not random at the beginning of period t_D-1, $\overline{S_{t_D-1}}$, and a shock component containing the vector of random earnings and preference shocks drawn at t_D-1, $\{\epsilon^i_{j,t_D-1}\}$.

For any given value of the deterministic and shock components of the state space, optimal consumption is obtained by comparing utility on a grid of possible consumption levels, for each of the possible choices of husbands' and wives' labor sectors and for the different possible savings choices. The labor decision and associated optimal consumption that maximizes total utility is chosen for that value of the state space.

At any deterministic state point, the expected value of V_{t_D-1} is obtained by Monte Carlo integration, that is, by taking draws from the shock vector distribution and averaging to obtain $EV_{t_D-1}(\overline{S_{t_D-1}})$. This expectation is calculated at a subset of the deterministic state points and the function is approximated for all other state points by a polynomial regression following an approximation method developed by Keane and Wolpin (1994, 1997). We denote this function as $Emax(t_D-1)$.

This procedure is repeated at age t_D-2. Using the recursive formulation of the value function, substituting the $Emax(t_D-1)$ function for the future component, the optimal decision is computed. Monte Carlo integration over the shock vector at t_D-2 provides $EV_{t_D-2}(\overline{S_{t_D-2}})$ for a given deterministic state point. A polynomial regression over a subset of the state points again provides an approximation to the function, denoted by $Emax(t_D-2)$. Repeating the

[34]We use information on reported earnings and do not explicitly incorporate minimum wage regulation. However, we trim out reported monthly wages over 100 million pesos as they are likely to be reported with error.

procedure back to the initial age provides the $Emax$ polynomial approximation at each age. The set of $Emax(t)$ functions fully describe the solution to the optimization problem.

5.2 Estimation Method

Model parameters are estimated by the Method of Simulated Moments (MSM). This method was chosen, in part, because it more easily accommodates missing state variables than does simulated maximum likelihood, which would require numerical integration over all possible values of missing state variables. Because only a few rounds of data were available, we calibrated the discount factor at 0.95. The fertility logit parameters were estimated separately and are presented in table C.1.

Our estimation approach uses information from the 2004 survey to construct the initial conditions and state variables (described in the previous section), simulates two periods ahead to get 2006 outcomes, and minimizes the distance between the actual and the simulated 2004/2006 outcomes. Some of the outcomes include 2004-2006 transitions.

Appendix A lists the set of data moments used in the estimation. There are 157 moments (M) and 47 estimated model parameters (K). The estimated parameter values are reported in table C.2 with standard errors in italics.

We next describe how standard errors are obtained. Denote by x_i^m an outcome measure of individual i, $i \in 1..N$, pertaining to the mth moment, $m = 1..M$. The Method of Simulated Moments estimator that we use is defined as:

$$\hat{\theta}_N = \arg\max_{\theta\in\Theta} \left[\frac{1}{N}\sum_{i=1}^{n}\left[x_i^m D_i^m \frac{N}{N^m} - \left(\frac{1}{R}\sum_{r=1}^{R}\sum_{k=1}^{K}\hat{x}_{irk}^m(\theta)\hat{D}_{irk}^m(\theta)\frac{N}{N^m}Pr(k|\Omega)\right)\right]\right]'_{1\times M} W_N^{-1} \left[\frac{1}{N}\sum_{i=1}^{n}\left[x_i^m D_i^m \frac{N}{N^m} - \left(\frac{1}{R}\sum_{r=1}^{R}\sum_{k=1}^{K}\hat{x}_{irk}^m(\theta)\hat{D}_{irk}^m(\theta)\frac{N}{N^m}Pr(k|\Omega)\right)\right]\right]_{M\times 1}$$

where D_i^m is an indicator for whether observation i is included in calculating moment condition m, $\hat{D}_{irk}^m$ is an indicator for whether the observation is included in moment m under simulation r when the individual is type k, and $N^m = \sum_{i=1}^{n} D_i^m$. The sum over k integrates over the unobserved types. For example, suppose the moment pertains to the wages of males in some age range who are working. In that case, $D_i^m = 1$ for males in a given age range who are working. $\hat{D}_{irk}^m = 1$ for males in that age range who are simulated to be working.

The weighting matrix W_N is an M by M diagonal matrix with the m^{th} diagonal elements equal to the sample variance of x_i^m.[35] Integrating over the unobservables, k, and assuming that $R \to \infty$ so that the simulation error goes to zero and the term in parentheses converges (uniformly in θ) to the limit, we get

$$\mu_i^m(\theta) = E(\hat{x}_{irk}(\theta)^m | \hat{D}_i^m(\theta) = 1) Pr(\hat{D}_i^m(\theta) = 1) \frac{N}{N^m}. \tag{1}$$

Defining

$$\mu_i^m = x_i^m D_i^m \frac{N}{N^m}, \tag{2}$$

we can rewrite the objective function as:

$$\hat{\theta}_N = \arg\max_{\theta \in \Theta} \left[\frac{1}{N} \sum_{i=1}^{n} \mu_i^m - \mu_i^m(\theta) \right]'_{1 \times M} W_N^{-1} \left[\frac{1}{N} \sum_{i=1}^{n} \mu_i^m - \mu_i^m(\theta) \right]_{M \times 1}$$

Taking first order conditions with respect to θ yields [36] :

$$\left[\frac{1}{N} \sum_{i \in S} \frac{\delta \mu_i^m}{\delta \theta} |_{\hat{\theta}_N} \right]' W_N^{-1} \left[\frac{1}{N} \sum_{i \in S} (\mu_i^m - \mu_i^m(\hat{\theta}_N)) \right] = 0 \tag{3}$$

A Taylor expansion of $\mu_i^m(\hat{\theta}_N)$ around the true parameter vector θ_0 yields:

$$\mu_i^m(\hat{\theta_N}) = \mu_i^m(\theta_0) + \frac{\delta \mu_i^m}{\delta \theta} |_{\theta^*} \cdot (\hat{\theta}_N - \theta_0) \tag{4}$$

for some θ^* between $\hat{\theta}_N$ and θ_0.

We obtain after rearranging:

$$\begin{aligned} \sqrt{N}(\hat{\theta}_N - \theta_0) \quad = \quad & \left[\left[\frac{1}{N} \sum_{i \in S} \frac{\delta \mu_i^m}{\delta \theta} |_{\hat{\theta}_N} \right]' W_N^{-1} \left[\frac{1}{N} \sum_{i \in S} \frac{\delta \mu_i^m}{\delta \theta} |_{\hat{\theta}^*} \right] \right]^{-1} \\ & \times \left[\frac{1}{N} \sum_{i \in S} \frac{\delta \mu_i^m}{\delta \theta} |_{\hat{\theta}_N} \right]' W_N^{-1} \left[\frac{1}{\sqrt{N}} \sum_{i \in S} (\mu_i^m - \mu^m(\theta_0)) \right]. \end{aligned}$$

[35] We do not use the optimal weighting matrix (the inverse of the variance of the moments), because of difficulties in inverting the matrix during the course of the optimization. However, the efficiency cost of not using the optimal weighting matrix is probably not that great. Altonji and Segal (1996) provide Monte-Carlo evidence of small-sample bias when the optimal weighting matrix is used.

[36] If the number of simulations $R \to \infty$, then the limiting objective is differentiable despite the original objective function not being differentiable.

Following Hansen (1981), we can obtain the estimator's asymptotic variance-covariance matrix as:

$$Asy.Var(\hat{\theta}_N) = \left(D_0' W_0^{-1} D_0\right)^{-1} D_0' W_0^{-1} V_0 W_0^{-1} \left(D_0' W_0^{-1} D_0\right)^{-1\prime},$$

where $D_0 = E\left[\frac{\delta \mu^m}{\delta \theta}|_{\theta_0}\right]$, $V_0 = E\left(\left[\mu_i^m - \mu_i^m(\theta_0)\right]\left[\mu_j^m - \mu_j^m(\theta_0)\right]\right)'$.

In computing the standard errors, D_0 is estimated using numerical derivatives of the model's moments at the estimated vector of parameters, V_0 is approximated by the sample variance-covariance of $\left[\tilde{x}_j^m - \tilde{\mu}_j^m(\theta_0)\right]$. The standard errors are corrected for the variance resulting from replacing the true model-implied moments by simulated moments.

6 Description of the data

The estimation and simulations are based on data from three sources: the *Encuesta de Proteccion Social* (EPS) longitudinal survey, linked administrative records of pension balances and contributions to retirement accounts (obtained from the Chilean supervising agency for pension fund administrators (the *Superintendency of Pensions* or SP) and data on the returns achieved by Chile's pension fund administrators (the *Administradoras de Fondos de Pensiones*).

The EPS survey was first administered in 2002 (originally under the name *Historia Laboral y de Seguridad Social*) by the Microdata Center of the University of Chile. Originally, the sampling frame was individuals affiliated with the AFP or the older INP pension systems. The survey data was then linked to the administrative records of the pension accounts of the sampled individuals. In 2004, 2006 and 2009 three follow-up surveys were administered, and the sample was augmented to include individuals that were not affiliated to any pension program, to obtain a total sample of 20,114 individuals, representative of the Chilean population in 2004. We use information on the 16,150 respondents who were interviewed in the 2006 round and use the survey weights to correct for attrition and non response.

The EPS questionnaire was designed specifically to study Chile's social protection programs including the pension system. It contains rich longitudinal information on socio-demographic variables, household composition, employment histories, earnings and assets. The data include retrospective employment histories back to 1981 as well as earnings from

2002 to 2006 and household assets in 2004-2006. The main variables used in our estimation are age, schooling level, schooling level of the spouse, an indicator for the birth of a child in the current year, ages of all children, 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 earnings and private household wealth.[37] We merge the household survey data with the administrative data on pension savings accumulations.

To arrive at our estimation sample, we apply the following restrictions to the EPS sample:

(i) First, it was decided the model would incorporate the rules of the AFP pension system, as the older INP system was phased out. We thus excluded from the estimation sample workers who reported only making contributions to a pension system other than AFP, which applied to 2,152 EPS respondents. The characteristics of these excluded households are summarized in tables B.1 and B.2. We do incorporate those workers who worked before 1980, and thus accumulated some pension rights under the previous pension system. In the model,the value of these rights is captured through the value of their Recognition Bond ("bono de reconocimiento"), which we add to the funds accumulated in the AFP account upon retirement.[38]

(ii) Second, incorporating marriage decisions is not feasible given the model's complexity. To limit the impact of this simplification, we set the initial age in our model to 35, an age at which most people's marital status has been determined, and we use in estimation individuals who are 35 or older in 2004, the initial year of our sample (4,899 households excluded by this restriction, see tables B.3 and B.4). We excluded respondents who reported getting married after the age of 35 (1,183 cases, see tables B.5 and B.6).

Finally, we dropped household with missing information in key variables and with inconsistencies across survey rounds with respect to age, education and civil status, for an additional 2,502 respondents excluded (see tables B.7 and B.8). The final sample contains 5,314 households, some consisting of a single person and some of a couple, for a total of 4,809 women and 4,309 men.

A potential concern with regard to these exclusion restrictions is whether we might dis-

[37] We construct a wealth measure that includes also the reported value of equity in major household assets, such as the home and car.

[38] We obtained a dataset on the recognition bond values from the Superintendence of Pensions, which we linked to the survey data.

proportionately be excluding poorer households, who are the target of the pension policies we are evaluating. We report in Table 1 the mean and quantiles of the earnings of working individuals above age 35 before and after the sample restrictions are applied. The distributions are very similar, except in the right tail. The estimation sample contains a slightly smaller proportion of wealthy households, which is unlikely to affect our conclusions.

Table 1: Effect of Sample Exclusions on the Distribution of Earnings

Annual Earnings (million pesos)		**mean**	**p10**	**p25**	**p50**	**p75**	**p90**
Before exclus.	Married men	4.8	1.2	1.9	2.8	4.6	8.4
	Single men	3.1	0.7	1.6	2.2	3.6	5.8
	Married wom.	3.1	0.6	1.2	1.9	3.6	7.2
	Single wom.	3.0	0.6	1.2	1.9	3.0	6.0
After exclus.	Married men	5.2	1.2	1.9	2.5	4.2	7.2
	Single men	2.7	0.6	1.4	2.0	3.0	5.4
	Married wom.	2.9	0.5	1.0	1.9	3.6	7.0
	Single wom.	2.7	0.6	1.1	1.9	3.0	5.8

Table 2 presents summary statistics for the estimation sample. Two thirds of the sample are couples, and most of the single households are women. Women are a lot less likely than men to be working (36.2% verses 74.9%). Among workers, women are slightly less likely to be working in the covered sector than men. The high average age of the sample (51.4 for men and 50.8 for women) is due to the fact that the estimation only incorporates workers over 35 years of age at the time of the first survey (2004). The high levels of mean assets are heavily skewed by a handful of respondents with very high wealth levels.[39] Table 3 describes the distribution of earnings, non-pension assets and pension assets, in millions of pesos. The high levels of mean assets partly reflect a handful of respondents with very high wealth levels.[40]

[39]This is the case even though the responses for each type of asset holdings (housing, cars, etc.) have been top coded at 1% to reduce the effect of outliers.

[40]This is the case even though the responses for each type of asset holdings (housing, cars, etc.) have been top coded at 1% to reduce the effect of outliers/miscoding.

Table 2: Summary Statistics (in 2004)

variable	**mean**
Couples (%)	66.9
Single Women (%)	22.0
Single Men (%)	11.1
Lab. Force Part. (wom., %)	36.2
Lab. Force Part. (men, %)	74.9
Formal sector* (wom., %)	59.5
Formal sector* (men, %)	61.4
Age (men)	51.4
Age (wom.)	50.8
Schooling (men, years)	8.7
Schooling (wom., years)	8.5
Children	3.0

Source: Encuesta EPS, Superintendencia de Pensiones

* as a fraction of those working

Table 3: **Distributon of Earnings, Non-Pension and Pension Assets in 2004**

variable	**mean**	**p10**	**p25**	**p50**	**p75**	**p90**
Annual Earnings (wom., MM PS)	2.2	0.5	1.0	1.6	2.6	4.8
Annual Earnings (men, MM PS)	5.0	1.0	1.6	2.2	3.6	6.0
Non-Pension assets** (MM PS)	13.0	0.0	2.5	7.0	15.0	27.9
Pension assets** (wom., MM PS)	2.5	0.0	0.0	0.0	0.5	4.2
Pension assets** (men, MM PS)	9.0	0.0	0.0	2.7	8.9	19.5

Source: Encuesta EPS, Superintendencia de Pensiones

Note: MM PS = Million Pesos

** The top 2% of pension values were trimmed in calculating these statistics to avoid sensitivity to outliers in the data

7 Within- and out-of-sample model fit

As previously noted, we use data from the 2004 and 2006 EPS surveys to estimate the model and then use the estimated model to forecast behavior until 2014, or five years after the introduction of the pension reform.[41] To evaluate the capacity of the the model to fit the data within sample, we simulate behavior in years 2005 and 2006 for all the individuals in the estimation sample using the 2004 data as the initial conditions. In addition, we do an assessment of out-of-sample fit of the model. Specifically, we simulate decisions until 2009, introducing the 2008 reform in the model in the way it was implemented in reality, and compare the model predictions with the observed information in the 2009 EPS round. The 2009 survey data were collected in the summer of 2009, about nine months after the introduction of the first phase of the pension reform. We did not use the 2009 data in the estimation, so this comparison represents an out-of-sample validation of the model.

7.1 Within-sample fit (2006 data)

Tables 4 to 9 compare the simulated and actual 2006 data on a number of dimensions for both couples and singles (men and women). As seen in tables 4, 6 and 8 (corresponding to couples, single females and single males) the model fits the distribution of numbers of children, labor force participation and experience for men and women well. It underpredicts the fraction of married and single males working in the formal sector. The fit is also good for earnings at lower percentiles, but the model does not capture well the right tail of the distribution (the 90 percentile) for males. The model has difficulties, though, in fitting some features of the asset distribution, such as the 90th percentile. Long right tails also result in standard deviations of the earnings and asset distributions that are also much larger in the data. These observations correspond to individuals who are very unlikely to rely on government provided pension benefits, so we do not expect this to impact our results.

[41] Some aspects of the reform were introduced in July 2008, but the more important changes started in 2009.

Table 4: **Within sample model fit (2006 data) - Couples (1)**

variable	mean	sd	p10	p25	p50	p75	p90
Children (model)	3.28	1.90	2.00	2.00	3.00	4.00	6.00
Children (data)	3.29	1.90	2.00	2.00	3.00	4.00	6.00
Men's LF Part (model)	0.77	0.42	0.00	1.00	1.00	1.00	1.00
Men's LF Part (data)	0.74	0.44	0.00	0.00	1.00	1.00	1.00
Wom.'s LF Part (model)	0.32	0.47	0.00	0.00	0.00	1.00	1.00
Wom.'s LF Part (data)	0.34	0.53	0.00	0.00	0.00	1.00	1.00
Men - formal sector (model)*	0.59	0.49	0.00	0.00	1.00	1.00	1.00
Men - formal sector (data)*	0.66	0.47	0.00	0.00	1.00	1.00	1.00
Wom. - formal sector (model)*	0.59	0.49	0.00	0.00	1.00	1.00	1.00
Wom. - formal sector (data)*	0.61	0.49	0.00	0.00	1.00	1.00	1.00
Men's work exp (model)	27.69	11.56	15.00	22.00	27.00	35.00	42.00
Men's work exp (data)	29.09	10.95	17.98	23.00	28.73	36.00	44.00
Wom.'s work exp (model)	5.05	7.56	0.00	0.00	1.50	8.00	16.00
Wom.'s work exp (data)	5.11	7.99	0.00	0.00	0.00	8.72	16.00

Source: EPS,SAFP records,* As a fraction of those working

Table 5: **Within sample model fit (2006 data) - Couples (2)**

variable	mean	sd	p10	p25	p50	p75	p90
Ann. earn-men (model)	3.6	2.5	1.2	1.9	3.1	4.7	6.7
Ann. earn-men (data)	5.1	4.5	1.2	1.9	2.4	4.2	7.2
Ann. earn-wom (model)	2.9	5.2	0.25	0.74	1.7	3.5	6.2
Ann. earn-wom (data)	2.7	2.9	0.49	0.96	1.9	3.1	6.0
Assets (MM PS) (model)	11.4	14.3	0.0	0.3	5.1	17.6	35.0
Assets (MM PS) (data)	14.5	38.8	0	3.0	7.7	15.1	28.0

Source: EPS, SAFP records

Table 6: **Within sample model fit (2006 data) - Single females (1)**

variable	mean	sd	p10	p25	p50	p75	p90
Children (model)	2.77	2.53	0.00	1.00	2.00	4.00	6.00
Children (data)	2.78	2.52	0.00	1.00	2.00	4.00	6.00
Wom's LF Part (model)	0.48	0.50	0.00	0.00	0.00	1.00	1.00
Wom's LF Part (data)	0.48	0.50	0.00	0.00	0.00	1.00	1.00
Wom.- formal sector (model)*	0.59	0.49	0.00	0.00	1.00	1.00	1.00
Wom.- formal sector (data)*	0.64	0.48	0.00	0.00	1.00	1.00	1.00
Wom. work exp (model)	9.72	11.24	0.00	1.00	4.00	16.00	26.00
Wom. work exp (data)	9.64	11.69	0.00	0.00	4.00	17.00	26.00

Source: EPS,SAFP records,* As a fraction of those working

Table 7: **Within sample model fit (2006 data) - Single females (2)**

variable	mean	sd	p10	p25	p50	p75	p90
Ann. earnings-wom (model)	2.9	4.4	0.2	0.8	2.0	3.6	5.9
Ann. earnings-wom (data)	2.5	2.3	0.6	1.1	1.9	3.0	5.4
Assets (MM PS) (model)	6.1	10.7	0	0	0.7	7.9	18.9
Assets (MM PS) (data)	12.9	25.8	0	2.0	7.0	15.0	28.2

Source: EPS, SAFP records

Table 8: **Within sample model fit (2006 data) - Single males (1)**

variable	mean	sd	p10	p25	p50	p75	p90
Children (model)	1.48	2.10	0.00	0.00	0.00	2.00	4.00
Children (data)	1.49	2.10	0.00	0.00	1.00	2.00	4.00
Men's LF Part (model)	0.66	0.47	0.00	0.00	1.00	1.00	1.00
Men's LF Part (data)	0.69	0.46	0.00	0.00	1.00	1.00	1.00
Men.- formal sector (model)*	0.51	0.50	0.00	0.00	1.00	1.00	1.00
Men.- formal sector (data)*	0.54	0.50	0.00	0.00	1.00	1.00	1.00
Men - work exp (model)	24.85	11.53	9.0	19.0	25.0	31.0	40.0
Men - work exp (data)	24.91	12.11	9.0	19.0	25.0	32.0	41.0

Source: EPS,SAFP records,* As a fraction of those working

Table 9: **Within sample model fit (2006 data) - Single males(2)**

variable	mean	sd	p10	p25	p50	p75	p90
Ann. earnings-men (model)	3.3	2.3	1.1	1.8	2.7	4.2	6.1
Ann. earnings-men (data)	3.2	25.3	0.6	1.4	2.0	3.0	5.4
Assets (MM PS) (model)	5.1	11.3	0	0	0	1.7	21.8
Assets (MM PS) (data)	11.4	24.2	0	1.0	5.6	15.0	25.0

Source: EPS,SAFP records

7.2 Out-of-sample fit (2009 data)

Tables 10 to 15 compare the 2009 data with the 2009 model simulations. As previously noted, the data were collected shortly after the reform started to be phased-in, while the model assumes that workers immediately and fully adjust to the new rules of the pension system. In the data, the fraction of survey respondents who reported knowing about the reform at the time of the 2009 round of interviews was still low (between a quarter and a third according to Behrman et al (2011)). Nonetheless, the model predicts well the distributions of numbers of children, labor force experience, and work experience for men and women. The model's predictions of mean annual earnings and of the distribution of earnings is close for both men and women, although it underpredicts the far right tail. Also, the prediction of the fraction of men and women working in the formal sector is lower than in the data. The model's predicted assets also do not accurately capture the skewness in the right tail of the asset distribution.

Table 10: **Out-of-sample model fit (2009 data) - Couples (1)**

variable	mean	sd	p10	p25	p50	p75	p90
Children (model)	3.30	1.91	2.00	2.00	3.00	4.00	6.00
Children (data)	3.29	1.87	2.00	2.00	3.00	4.00	6.00
Men's LFP (model)	0.73	0.44	0.00	0.00	1.00	1.00	1.00
Men's LFP (data)	0.70	0.46	0.00	0.00	1.00	1.00	1.00
Wom.'s LFP (model)	0.29	0.45	0.00	0.00	0.00	1.00	1.00
Wom.'s LFP (data)	0.31	0.46	0.00	0.00	0.00	1.00	1.00
Men formal sector (model)*	0.60	0.49	0.00	0.00	1.00	1.00	1.00
Men formal sector (data)*	0.64	0.48	0.00	0.00	1.00	1.00	1.00
Wom. formal sector (model)*	0.60	0.49	0.00	0.00	1.00	1.00	1.00
Wom. formal sector (data)*	0.61	0.49	0.00	0.00	1.00	1.00	1.00
Men's work exp (model)	30.02	11.33	18.00	25.00	30.00	37.00	43.00
Men's work exp (data)	30.21	12.36	17.45	25.00	30.00	37.99	45.86
Wom.'s work exp (model)	5.79	7.66	0.00	0.00	3.00	8.50	17.00
Wom.'s work exp (data)	7.62	9.96	0.00	0.00	2.00	13.50	23.00

Source: EPS, SAFP records, and own simulations based on estimated model

Table 11: **Out-of-sample model fit (2009 data) - Couples (2)**

variable	mean	sd	p10	p25	p50	p75	p90
Ann earnings men (model)	3.55	2.46	1.23	1.92	3.00	4.63	6.56
Ann earnings men (data)	3.67	4.52	1.20	1.91	2.40	4.08	6.00
Ann earnings wom. (model)	2.76	4.93	0.25	0.74	1.71	3.33	5.78
Ann earnings wom. (data)	2.64	2.70	0.48	0.96	1.80	3.00	6.18
Assets (MM PS) (model)	12.48	16.53	0.02	0.16	3.23	21.03	42.91
Assets (MM PS) (data)	16.01	60.71	0.00	0.00	8.00	17.34	30.80

Source: EPS, SAFP records, and own simulations based on estimated model

Table 12: **Out-of-sample model fit (2009 data) - Single females (1)**

variable	mean	sd	p10	p25	p50	p75	p90
Children (model)	2.85	2.45	0.00	1.00	2.00	4.00	6.00
Children (data)	2.87	2.42	0.00	1.00	2.00	4.00	6.00
Wom's LFP (model)	0.44	0.50	0.00	0.00	0.00	1.00	1.00
Wom's LFP (data)	0.41	0.49	0.00	0.00	0.00	1.00	1.00
Wom. formal sector (model)	0.57	0.50	0.00	0.00	1.00	1.00	1.00
Wom. formal sector (data)	0.63	0.48	0.00	0.00	1.00	1.00	1.00
Wom.'s work exp (model)	10.51	10.88	0.00	2.50	6.00	16.50	27.00
Wom.'s work exp (data)	14.39	12.75	0.00	1.00	13.00	23.50	33.00

Source: EPS, SAFP records, and own simulations based on estimated model

Table 13: **Out-of-sample model fit (2009 data) - Single females (2)**

variable	mean	sd	p10	p25	p50	p75	p90
Ann earnings wom. (model)	2.84	4.84	0.22	0.82	2.01	3.69	5.87
Ann earnings wom. (data)	2.53	2.35	0.60	1.05	1.91	3.00	5.52
Assets (MM PS) (model)	5.44	10.32	0.00	0.00	0.22	6.88	18.22
Assets (MM PS) (data)	12.25	41.78	0.00	0.00	5.38	15.00	28.04

Source: EPS, SAFP records, and own simulations based on estimated model

Table 14: **Out-of-sample model fit (2009 data) - Single males (1)**

variable	mean	sd	p10	p25	p50	p75	p90
Children (model)	1.86	2.23	0.00	0.00	1.00	3.00	5.00
Children (data)	1.89	2.22	0.00	0.00	1.00	3.00	5.00
Men's LFP (model)	0.60	0.49	0.00	0.00	1.00	1.00	1.00
Men's LFP (model)	0.64	0.48	0.00	0.00	1.00	1.00	1.00
Men. formal sector (model)	0.49	0.50	0.00	0.00	0.00	1.00	1.00
Wom. formal sector (data)	0.53	0.50	0.00	0.00	1.00	1.00	1.00
Men.'s work exp (model)	27.66	11.08	13.00	22.00	28.00	34.00	41.00
Wom.'s work exp (data)	25.94	14.09	0.00	20.00	28.00	35.00	43.00

Source: EPS, SAFP records, and own simulations based on estimated model

Table 15: **Out-of-sample model fit (2009 data) - Single males(2)**

variable	mean	sd	p10	p25	p50	p75	p90
Ann earnings men (model)	3.45	2.42	1.16	1.84	2.89	4.43	6.47
Ann earnings men (data)	2.87	3.33	0.60	1.50	2.11	3.12	5.40
Assets (MM PS) (model)	5.29	12.22	0.00	0.00	0.00	0.00	24.30
Assets (MM PS) (data)	11.21	25.88	0.00	0.00	3.10	13.88	26.00

Source: EPS, SAFP records, and own simulations based on estimated model

8 Short-term reform impacts

We next use the estimated model to evaluate the effects of the pension reform up until the year 2014. The sample used in estimation is 35 or older in 2004, which makes the sample 45 or older in the year 2014. We simulate the labor force participation choices, savings choices, pension accumulations and withdrawals, assuming that the reform was introduced in the year 2009 and that it was a surprise at the time of its introduction.[42] That is, we estimate the structural model parameters without the reform and then resolve the Emax values with the reform in place. In simulating people's decision-making, we simulate pre-2008 choices using the parameters without the reform and then simulate post-2009 choices with and without the reform in place. A comparison of these two simulations gives us the effect of the pension reform.[43] Along with simulating choices and savings, we also simulate fertility (possible for women younger than age 40), divorce (possible for women under age 60), and survival.

The tables below describe the pension levels, poverty rates, labor force participation patterns (including formal/informal sector break-down), and pension wealth with and without the reform. [44] If a couple qualifies for the PASIS pension, our simulation assigns the PASIS pension to the woman (only one member of the household can get the PASIS).

[42] If the reform had been anticipated, it could have affected the behavior of individuals in earlier years.

[43] For the years 2004-2009, we use actual market returns on assets as the return on pensions in the simulation. For years 2010 or later, which is outside the range of the data, we use an average of the 2004-2009 returns, which equals 6.3%.

[44] To keep the model tractable, we assumed that everybody chooses the option of programmed pension withdrawals. In computing the programmed withdrawals, we used the life tables RV-2004 published by the *Superintendia de Pensiones*. The 2009, 2010 and 2011rates of return were used for the corresponding years. To discount years more than 20 years in the future, the twentieth discount rate was repeated. For years after 2011, the 2011 vector was used. For years before 2009, a single discount rate of 5% was used.

8.1 Reform impacts on pension withdrawals

Table 16 shows the mean and percentiles of annual pension savings withdrawal amounts for women age 60-79 in 2014 (age 50-69 in the 2004 data), with and without the pension reform, reported in thousands of pesos. Without the reform, more than 25% of women are predicted to have 0 or almost 0 pension withdrawal. These correspond in large part to married women, who do not qualify for PASIS due to their husband's income. The reform leads to a substantial increase in the pension withdrawal amounts for women, throughout the entire distribution, because of the higher coverage rate, the increased benefit levels of the Solidarity Pension System system relative to the PASIS and to the introduction of the per-child bonus (the *bono por hijo*). The average pension amount received by women is more than double after the reform for ages 65 and older.

Table 16: **Predicted annual pension withdrawal amounts for women age 60-79, without and with reform (in thousands of pesos)**

			Without reform			
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
60-64	306.76	0.00	0.00	50.70	227.05	1043.9
65-69	600.91	0.00	18.50	450.00	450.00	1096.5
70-74	361.99	0.00	0.00	450.00	450.00	648.31
75-79	424.16	0.00	450.00	450.00	450.00	900.00
			With reform			
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
60-64	438.39	51.83	77.75	151.20	316.72	1153.8
65-69	1263.6	915.92	947.07	978.45	1041.3	1712.5
70-74	1028.9	900.00	936.88	970.67	1008.2	1102.9
75-79	1019.8	900.00	920.82	979.19	1045.1	1098.0

Table 17 shows the annual pension withdrawals for men. Before age 64, pensions come exclusively from contributions made during working years. As described below, the reform is expected to slightly lower contribution densities, resulting in lower contributory pensions. For men age 65 and older, pension withdrawals increase at the low end of the distribution due to the reform. If a household qualifies for the PASIS benefit before the reform, our simulations give the PASIS to the woman, which mainly accounts for the 10% of lowest male pension values pre-reform (the column of zeros). After the reform, men age 65 and older with

pension withdrawals below the median all get at least 900,000 pesos, which is the PBS level. The reform also modestly increases age 65+ male pension levels at higher deciles because they qualify for the pension supplement, or *Aporte Previsional Solidario* (APS).

Table 17: **Predicted annual pension withdrawal amounts for men age 60-79, without and with reform in thousands of pesos**

			Without reform			
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
60-64	717.84	0.00	0.00	0.00	1243.1	1943.8
65-69	1084.4	16.45	450.00	900.00	1279.6	2427.5
70-74	1137.1	0.00	450.00	900.00	1423.0	2744.1
75-79	663.36	0.00	72.01	450.00	900.00	900.00
			With reform			
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
60-64	629.71	0.00	0.00	0.00	1163.2	1795.0
65-69	1556.7	900.00	900.00	1150.1	1773.3	2548.2
70-74	1602.4	900.00	900.00	1055.9	1900.8	2826.4
75-79	1092.8	900.00	900.00	900.00	922.34	1400.7

Table 18 shows the ratio of women's and men's pensions. Without the reform, the mean level of pension withdrawals for women is substantially smaller than that of men, about half as large between ages 65-69. The ratio tends to be more equal at older ages, when many of the men have exhausted their pension funds and the household relies on the PASIS. With the reform, women's pension withdrawal amounts increase substantially. In the first two quartiles of the distribution amounts, pension withdrawal amounts are about equal or even slightly higher for women due in part to the child pension benefit. Above the median, there remains a significant gender disparity, but it is much smaller than prior to the reform.

Table 18: **Ratio of predicted womens and mens annual pension withdrawals in 2014, mean and percentiles age 60-79, without and with the reform**

Without reform						
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
60-64	0.43	.	.	.	0.18	0.54
65-69	0.55	0.00	0.04	0.50	0.35	0.45
70-74	0.32	.	0.00	0.50	0.32	0.24
75-79	0.64	.	6.25	1.00	0.50	1.00
With reform						
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
60-64	0.70	.	.	.	0.27	0.64
65-69	0.81	1.02	1.05	0.85	0.59	0.67
70-74	0.64	1.00	1.04	0.92	0.53	0.39
75-79	0.93	1.00	1.02	1.09	1.13	0.78

*A value of . indicates that mens pension withdrawal value was zero.

8.2 Reform impacts on poverty rate

Table 19 shows the percentage of households living in poverty by age category (of the female for couples), where households are defined as poor if their annual household income, including receipt of any pension income, is less than 400,000 pesos (poverty measure 1) or 500,000 pesos (poverty measure 2) annually.[45] The threshold used to defined poverty is important, as the PASIS pension level is in between the two thresholds considered (450,000). As a result, many older households who receive PASIS before the reform are deemed poor per measure 2, but not measure 1, and will not be poor by either measure once they receive the PBS. The reform dramatically reduces poverty for persons who qualify for the PBS.

[45]The 500,000 annual pesos threshold was obtained from the poverty threshold used by the Economic Commission for Latin America and the Caribbean (ECLAC) for Chile in 2003. ECLAC defines an urban and a rural poverty line based on monthly income (43.712 and 29,473 pesos respectively) which were weighted by the fraction of the Chilean population living in urban areas (86.6%) and annualized and rounded (the exact number is 501,712 pesos). The 400,000 pesos measure is presented as a sensitivity check.

Table 19: **Predicted Percent of households living in poverty in 2014, without and with the reform**

Without reform		
age group	**poverty rate #1**	**poverty rate #2**
45-49	17.30	17.89
50-54	16.86	17.57
55-59	19.10	19.92
60-64	36.09	39.24
65-69	0.00	38.31
70-74	0.00	45.23
75-79	0.00	62.81
With reform		
age group	**poverty rate #1**	**poverty rate #2**
45-49	16.92	17.56
50-54	15.91	16.54
55-59	19.02	19.62
60-64	34.92	36.03
65-69	0.00	0.00
70-74	0.00	0.00
75-79	0.00	0.00

*A household is defined as poor under measure #1 if household income, including pension withdrawals, is less then 400000 pesos. Poverty measure #2 uses a cut-off of 500000 pesos.

8.3 Reform impacts on contribution density

Table 20 shows the simulated effect of the pension reform on the contribution density distribution for women up to age 64. The contribution density is defined as the number of years spent working in the covered sector divided by the potential number of years worked since age 18 (age-18). Women age 45-49 spend on average 19% of their potential working years in the covered sector without the reform. The reform leads to almost no change in the contribution density patterns for women.

Table 21 similarly shows the simulated effect of the reform on the contribution density for men up to age 65. Men spend on average about half of their potential working years in the covered sector. The reform hardly affects at all the density of contributions on average. There are small increases in the contribution densities for men in the higher quantiles of the distribution.

Table 20: **Mean and percentiles of predicted contribution density distribution in 2014 for women age 45-59, without and with reform**

			Without reform			
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
45-49	0.19	0.00	0.03	0.13	0.29	0.48
50-54	0.16	0.00	0.00	0.10	0.25	0.43
55-59	0.16	0.00	0.00	0.09	0.24	0.45
60-64	0.12	0.00	0.00	0.05	0.15	0.37
			With reform			
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
45-49	0.19	0.00	0.02	0.13	0.29	0.48
50-54	0.16	0.00	0.00	0.10	0.25	0.43
55-59	0.16	0.00	0.00	0.09	0.24	0.45
60-64	0.12	0.00	0.00	0.05	0.15	0.37

*density = ratio of years of contribution divided by age-18

Table 21: **Mean and percentiles of predicted contribution density distribution in 2014 for men age 45-64, without and with the reform***

Without reform						
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
45-49	0.51	0.04	0.29	0.52	0.75	0.90
50-54	0.49	0.00	0.22	0.53	0.78	0.91
55-59	0.43	0.00	0.15	0.43	0.70	0.85
60-64	0.41	0.00	0.11	0.42	0.70	0.82
With reform						
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
45-49	0.51	0.04	0.29	0.52	0.76	0.90
50-54	0.49	0.00	0.22	0.53	0.79	0.94
55-59	0.44	0.00	0.16	0.43	0.70	0.86
60-64	0.41	0.00	0.11	0.42	0.70	0.82

*density=ratio of years of contribution divided by age-18

8.4 Reform impacts on labor supply and covered sector work

Tables 22 and 23 consider the effects of the pension reform on labor supply for women and men, including the choice between working in the covered and uncovered sectors. The reform appears to have very little effect on overall labor supply for women, except at older ages (age 60+) where we observe higher rates of not working by about 0.7-1.1 percentage points. The percentage of younger women (age 54 and below) working in the covered sector declines slightly with the reform, by about one percentage point, and the percentage of women age 45-49 working in the uncovered sector increases. For men, the reform generates a decrease the rates of nonworking by about 1-2 percentage points for ages 45-59 and and increase in the rates of not working after age 60, especially after age 65. The rates of working in the covered sector increase up through age 54 and then stay roughly the same at higher ages. There are no observed significant increases in the percent who work in the uncovered sector.

As seen in Table C.2, the estimated wage returns to education are much larger in the covered (formal) than in the uncovered (informal) sectors. For men, each year of education gives a return of 11% in the covered sector and basically zero in the uncovered sector. Women get a return of 9.8% in the covered sector and zero in the uncovered sector. This large disparity in returns to education across sectors implies that more educated workers

Table 22: **Predicted percent not working or working in covered or uncovered jobs in 2014 for women, age 45-69, without and with the reform**

		Without reform	
age group	**not working**	**work in cov. sector**	**work in uncov. sector**
45-49	48.0	30.5	21.5
50-54	47.9	29.1	23.1
55-59	49.9	27.2	22.9
60-64	93.4	2.81	3.81
65-69	92.1	2.64	5.21
		With reform	
age group	**not working**	**work in cov. sector**	**work in uncov. sector**
45-49	47.8	29.1	23.1
50-54	48.3	28.8	22.9
55-59	50.6	27.5	21.9
60-64	94.0	2.58	3.37
65-69	93.3	2.82	3.83

*The model imposes the restriction that people aged 70 and older do not work.

Table 23: **Predicted percent not working or working in covered or uncovered jobs in 2014 for men, age 45-69, without and with the reform**

		Without reform	
age group	**not working**	**work in cov. sector**	**work in uncov. sector**
45-49	14.6	51.2	34.2
50-54	15.8	46.6	37.6
55-59	24.6	39.0	36.4
60-64	40.9	29.4	29.8
65-69	76.6	8.91	14.5
		With reform	
age group	**not working**	**work in cov. sector**	**work in uncov. sector**
45-49	13.5	53.0	33.6
50-54	13.3	49.5	37.2
55-59	23.6	40.5	35.8
60-64	41.1	29.7	29.2
65-69	80.0	7.39	12.7

*The model imposes the restriction that people aged 70 and older do not work.

will be less likely to switch to uncovered sector work than less educated workers under the reform. Also, average education levels have been rising over time in Chile with successive cohorts, so the disincentives induced by the reform to work in the covered sector are likely to be less pronounced for younger cohorts.

8.5 Reform impacts on pension savings accumulations

Tables 24 and 25 show the amount of pension accumulations for men and women at the typical ages of retirement (age 60 for women and age 65 for men).

Table 24: **Predicted mean and percentiles of pension savings distribution in 2014 for women at age 60, without and with the reform, in thousands of pesos**

			Without reform			
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
60	4451.256	0.00	0.0000	921.0921	4180.796	15978.10
			With reform			
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
60	6782.202	751	1127.205	2461.058	7028.407	19662.95

Table 25: **Predicted mean and percentiles of pension savings distribution in 2014 for men at age 65, without and with reform in thousands of pesos**

			Without reform			
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
65	12508	0.00	695.21	10396	14322	30015
			With reform			
age group	**mean**	**P10**	**P25**	**P50**	**P75**	**P90**
65	11938	0.00	342.81	6763.2	14299	29921

The pension reform greatly increases women's pension accumulations, from an average of 4451 thousand pesos to 6782 thousand pesos. There are increases throughout the pension savings distribution. Given the lack of a significant increase in labor supply, the increase in pension accumulations most likely comes mainly from the per child pension benefit. Table 26 shows the pension accumulations for men, which decline some at lower percentiles and stay

roughly the same at higher percentiles. The increase in women's pensions and the decrease in men's pensions both serve to reduce the gender gap.

8.6 Reform impacts on full-time and part-time work

Table 26 shows the predicted effects of the reform on women working, distinguishing between not working, working full-time or working part-time. The simulation results that the pattern of part-time verses full-time employment is very little affected by the reform. However, as previously noted, the rate of not-working increases for women age 60 and older. Table 27 presents the effects on labor supply for men (for whom part-time work is not an option).[46] The reform is associated with a higher rate of working at ages 45-64 by about 1-2 percentage points. For both men and women, there are no significant disincentive effects on working until older ages (60-69).

Table 26: **Predicted percent not working, working full-time or working part-time in 2014 for women age 45-69 by age group, with and without the reform**

Without reform			
age group	**not working**	**working full-time**	**working part-time**
45-49	48.0	40.0	12.0
50-54	47.9	43.6	8.52
55-59	49.9	40.2	9.88
60-64	93.4	4.40	2.22
65-69	92.1	4.66	3.20
With reform			
age group	**not working**	**working full-time**	**working part-time**
45-49	47.8	40.0	12.2
50-54	48.3	43.2	8.46
55-59	50.6	40.9	8.58
60-64	94.0	3.74	2.22
65-69	93.3	3.77	2.89

*The model restricts individuals age 70 or older not to work

[46] Adding a part-time option in the model for men was costly in terms of tractability and did not seem as crucial as for women.

Table 27: **Predicted percent not working or working in 2014 for men age 45-79, without and with reform**

	Without reform	
age group	**not working**	**working**
45-49	14.6	85.4
50-54	15.8	84.2
55-59	24.6	75.4
60-64	40.9	59.1
65-69	76.6	23.4
	With reform	
age group	**not working**	**working**
45-49	13.5	86.5
50-54	13.3	86.7
55-59	23.6	76.4
60-64	41.1	58.9
65-69	80.0	20.0

*The model restricts individuals age 70 or older not to work.

8.7 Reform impacts on work around typical retirement ages

Table 28 and Table 29 show working patterns (not working, full-time work and part-time work) around typical ages of retirement (ages 55-70) for women and men. The fraction of women not working increases over all the age categories. For men, the reform does not affect much the proportion working until age 63, after which fewer men work with the reform. Also, the working rates of men age 55-56 are lower by about 3 percentage points with the reform.

Table 28: **Working patterns around the age of retirement in 2014 for women age 55-70, without and with the reform**

		Without reform	
age group	**not working**	**working full-time**	**working part-time**
55-56	50.7	37.8	11.5
57-58	46.8	42.2	11.0
59-60	79.3	18.0	2.64
61-62	92.9	4.89	2.23
63-64	91.8	4.75	3.47
65-66	93.6	3.92	2.46
67-68	91.0	5.34	3.67
69-70	95.6	2.41	1.95
		With reform	
age group	**not working**	**working full-time**	**working part-time**
55-56	52.1	38.1	9.86
57-58	47.1	43.3	9.64
59-60	79.8	18.3	1.98
61-62	93.8	4.01	2.15
63-64	92.1	4.26	3.64
65-66	94.4	3.06	2.52
67-68	92.4	4.21	3.40
69-70	96.5	2.22	1.29

*The model restricts individuals age 70 and older to not work

Table 29: **Working patterns around the age of retirement in 2014 for men age 55-70, without and with the reform**

	Without reform	
age group	**not working**	**working full-time**
55-56	16.5	83.5
57-58	26.0	74.0
59-60	36.4	63.6
61-62	33.3	66.7
63-64	49.1	50.9
65-66	74.3	25.7
67-68	79.2	20.8
69-70	88.6	11.4
	With reform	
age group	**not working**	**working full-time**
55-56	15.5	84.5
57-58	25.7	74.3
59-60	35.8	64.2
61-62	33.2	66.8
63-64	50.3	49.7
65-66	77.7	22.3
67-68	81.4	18.6
69-70	91.5	8.51

*The model restricts individuals age 70 or older to not work

9 Long-term reform impacts and alternative designs

Next, we use the estimated model to evaluate the long-term effects of the pension reform on individual outcomes but also government outlays and tax revenue. We also compare these variables across alternative pension designs. To do so, we consider the younger cohorts in our estimation sample (specifically, individuals born in 1964 or later) and simulate their lifetime decisions and outcomes, as well as the present discounted value (PDV) in 2009 of their tax payments, and collected government-financed benefits. The latter include the child subsidy, the new minimum pension (SPS), as well as the old PASIS and minimum pension guarantee (MPG). The individuals simulated are between 35 and 40 in 2004. The scenarios we consider are the following:

1. The actual reform is implemented in 2009 (baseline)
2. The old system is left in place (no reform)
3. The actual reform is implemented in 2009 but the minimum pension is not tapered (no tapering)
4. The actual reform is implemented in 2009 but without the child bonus (no bonus)
5. The actual reform is implemented in 2009 but without the new asset division upon divorce (no divorce rule)
6. The old system is left in place without the MPG (no mpg)
7. The old system is left in place without the PASIS (no pasis)

The policy changes are assumed to be unanticipated so that decisions until 2008 are governed by pre-reform expectations. The tables below describe the differences in lifetime outcomes under the different scenarios. Our assumptions are otherwise the same as in the short-run reform impact simulations.

9.1 Long-term costs of the reform

Tables 30 and 31 show the difference in long-term outcomes under the baseline vs. no reform scenarios. The present discounted value of the increase in lifetime government payments

due to the reform are predicted to be 1.86 and 1.62 million pesos per capita on average for men and women respectively. The child subsidy accounts for about a sixth of the total cost (0.66 million pesos paid to women in 2009 present value), and about a third of the total payments made to women. The child subsidy does not appear to create strong positive or negative labor supply incentives (remember that the subsidy is not conditional on a career interruption on the part of the mother). The same is true of the change in the asset division rule upon divorce.[47]

Table 30: **Comparison of lifetime outcomes (women): Reform vs. no Reform**

variable	**mean**	**p10**	**p25**	**p50**	**p75**	**p90**
Δ PDV Child sub. payments	0.66	0.30	0.30	0.59	0.89	1.19
Δ PDV SPS payments	1.41	0.00	0.68	1.54	2.10	2.53
Δ PDV MPG payments	-0.01	0.00	0.00	0.00	0.00	0.00
Δ PDV PASIS payments	-0.20	-0.88	-0.08	0.00	0.00	0.00
Δ PDV all gvt. payments	1.86	0.59	1.19	1.93	2.52	3.05
Δ PDV Taxes collected	0.05	-1.19	-0.03	0.00	0.20	1.31
Δ PDV Consumption	0.11	-0.01	0.03	0.10	0.18	0.29
Δ PDV Utility	-0.05	-0.23	-0.10	0.01	0.01	0.02
Δ Years worked	-0.05	0.00	0.00	0.00	0.00	0.00
Δ Years formal	-0.06	-1.00	0.00	0.00	0.00	1.00
Δ Contr. density	-0.00	-0.04	0.00	0.00	0.00	0.04
Pension benefits (baseline)	1.67	0.43	0.68	1.05	1.48	2.08
Pension benefits (alternative)	0.89	0.10	0.25	0.45	0.90	1.32

Source: Own simulations based on estimated model

Tables 31 and 30 do predict that the reform will increase the lifetime contribution densities and formal sector participation of between 10 and 25% of men. The extra tax revenue offsets about a sixth of the reform cost. This is not related to the tapering of the new minimum pension as discussed in the next subsection. Rather, this is due to the removal of disincentives to formal work and saving associated with the old minimum pension guarantee and the narrowly means-tested PASIS pension. [48]

Overall, the new benefits are around ten times as costly than the previous safety net.

[47] The tables comparing outcomes between the baseline and the "no bonus" and "no divorce rule" scenarios are available upon request

[48] This is apparent when comparing outcomes in the no reform case, but removing either the old MPG or PASIS benefits. These tables are not shown in the text to conserve space, but are available upon request.

Table 31: **Comparison of lifetime outcomes (men): Reform vs. no Reform**

variable	mean	p10	p25	p50	p75	p90
Δ PDV SPS payments	1.83	0.62	1.43	1.85	2.40	2.92
Δ PDV MPG payments	-0.06	-0.16	-0.03	0.00	0.00	0.00
Δ PDV PASIS payments	-0.16	-0.63	-0.01	0.00	0.00	0.00
Δ PDV all gvt. payments	1.62	0.43	1.30	1.67	2.04	2.62
Δ PDV Taxes collected	0.58	-0.08	0.00	0.00	0.73	2.55
Δ PDV Consumption	0.04	-0.17	-0.03	0.06	0.18	0.33
Δ PDV Utility	0.07	-0.00	0.00	0.01	0.06	0.17
Δ Years worked	0.40	-1.00	0.00	0.00	0.00	3.00
Δ Years formal	0.53	0.00	0.00	0.00	0.00	3.00
Δ Contr. density	0.02	0.00	0.00	0.00	0.00	0.12
Pension benefits (baseline)	1.31	0.49	0.67	0.99	1.61	1.89
Pension benefits (alternative)	1.27	0.24	0.52	0.92	1.22	1.65

Source: Own simulations based on estimated model

This is not surprising given the latter's low coverage and generosity.

9.2 Tapering or no tapering

Tables 33 and 32 compare the baseline reform with the "no tapering" scenario. This allows us to show that the tapering of the minimum pension accounts for nearly half of the total cost of the reform. This cost is not offset by an improvement in formality for either men or women which was expected to improve tax revenue.

Theoretically tapering reduces the implicit marginal tax on pension contributions created by flat, top-up minimum pension benefits (see figure 2). In our case, the old minimum pension guarantee created a 100% implicit tax on contributions for individuals who expected with certainty that they would benefit from it. The new system is designed to impose only a 30% implicit tax on contributions thanks to the tapering. However, this also implies mechanically that a larger fraction of the population will be subject to that (lower) implicit tax. Indeed, one can think of it as "spreading" the implicit tax on a larger number of individuals. The effect is thus theoretically ambiguous, and its magnitude undetermined.

Our simulations show that the positive incentives expected from the tapering of the minimum pension are not likely to materialize. This is due mostly to the fact that implicit

Table 32: **Comparison of lifetime outcomes (women): Tapering vs. no Tapering**

variable	mean	p10	p25	p50	p75	p90
Δ PDV Child sub. payments	0.00	0.00	0.00	0.00	0.00	0.00
Δ PDV SPS payments	0.88	0.00	0.27	0.85	1.44	1.79
Δ PDV MPG payments	0.00	0.00	0.00	0.00	0.00	0.00
Δ PDV PASIS payments	0.00	0.00	0.00	0.00	0.00	0.00
Δ PDV all gvt. payments	0.88	0.00	0.27	0.85	1.44	1.79
Δ PDV Taxes collected	0.01	-0.12	0.00	0.00	0.00	0.08
Δ PDV Consumption	0.05	0.00	0.01	0.04	0.08	0.12
Δ PDV Utility	-0.09	-0.29	-0.26	0.00	0.00	0.01
Δ Years worked	-0.02	0.00	0.00	0.00	0.00	0.00
Δ Years formal	0.07	0.00	0.00	0.00	0.00	0.00
Δ Contr. density	0.00	0.00	0.00	0.00	0.00	0.00
Pension benefits (baseline)	1.67	0.43	0.68	1.05	1.48	2.08
Pension benefits (alternative)	1.46	0.37	0.52	0.81	1.11	1.89

Source: Own simulations based on estimated model

Table 33: **Comparison of lifetime outcomes (men): Tapering vs. no Tapering**

variable	mean	p10	p25	p50	p75	p90
Δ PDV SPS payments	1.07	0.00	0.31	1.28	1.66	1.91
Δ PDV MPG payments	0.00	0.00	0.00	0.00	0.00	0.00
Δ PDV PASIS payments	0.00	0.00	0.00	0.00	0.00	0.00
Δ PDV all gvt. payments	1.07	0.00	0.31	1.28	1.66	1.91
Δ PDV Taxes collected	-0.11	-0.19	0.00	0.00	0.00	0.00
Δ PDV Consumption	0.05	0.00	0.02	0.04	0.08	0.13
Δ PDV Utility	0.01	-0.01	-0.00	0.00	0.01	0.03
Δ Years worked	-0.01	0.00	0.00	0.00	0.00	0.00
Δ Years formal	-0.12	0.00	0.00	0.00	0.00	0.00
Δ Contr. density	-0.01	0.00	0.00	0.00	0.00	0.00
Pension benefits (baseline)	1.31	0.49	0.67	0.99	1.61	1.89
Pension benefits (alternative)	1.07	0.45	0.53	0.76	1.12	1.47

Source: Own simulations based on estimated model

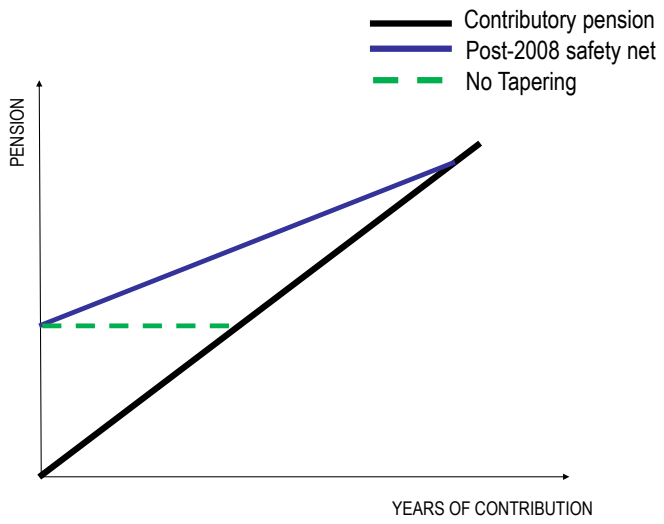

Figure 2: Pension benefit levels with and without minimum pension tapering

marginal tax effects appear too small to sway many individuals away from the formal sector. Further, small positive effects on tax revenue from the reduction in the implicit tax *rate*, are offset by losses due the addition of individuals to the tax *basis*. Tables 33 and 32 also show that tapering mostly improves the middle of the distribution of pension benefits. In other words, this feature of the reform operates as a transfer that is not targeted to the poorest retirees.

9.3 Short-run vs. Long-run behavioral responses

It is interesting to contrast these predictions to the short-run behavioral responses described earlier. First, it appears that the small average changes in LFP and formal sector participation predicted for the short-run can compound into sizeable fiscal impacts over the life time of a cohort. Second, the increase in formal sector participation predicted for younger men in the short-run are expected to outweigh the negative short-run responses predicted for older men. For older men, short-term impacts are larger than long-term impacts because the cohorts of individuals who experience the reform in their old age are not able to anticipate it and adjusting their labor supply and saving decisions early on. In contrast, due to state dependence, the short-term responses attributed to younger individuals are likely to be magnified in the long run. Our structural approach allows us to overcome this general limita-

tion of short-run policy evaluation and capture both the anticipatory and the compounding effects.

10 Conclusions

The simulations indicate the following impacts of the pension reform on pension withdrawals, pension savings, labor supply, retirement and the government budget:

(i) The pension reform significantly increases the level of pension withdrawals for women, who before the reform were mainly getting pension income through the PASIS welfare pension. The reform also leads to modest increases in the pension withdrawal amounts for males at the lower end of the pension withdrawal distribution. The level of women's pension withdrawals after the reform is equal to that of men in the first two quartiles and the gender gap is much reduced across the upper quartiles.

(ii) The pension reform largely eliminates old-age poverty (given our definitions of poverty). The pre-reform poverty rates for people aged 60 or younger are fairly sensitive to the measure used to define poverty, in particular, whether receipt of the PASIS pension qualifies as being poor. The pension reform leads to a slight increase in poverty rates for the younger age groups due to work disincentive effects.

(iii) In the short-run, simulations indicate a disincentive effect of the reform on working in the covered sector for men aged 63 and older and women age 50 and older. As retirement nears, incentives to contribute to the pension system are lower than before the reform due to higher expected income in retirement. However, younger men and women show modest increases in formal sector participation which offset the above-mentioned disincentives in the long-run simulations.

(iv) We anticipate that the new system will be ten times as costly as the old system, owing to its much larger coverage and benefit levels.

(v) Attempts to make the reformed pension system more incentive-compatible by tapering-off non-contributory benefits with pension accumulation levels are not shown to improve formal sector participation and tax revenue significantly. In addition, this feature accounts for half of the total cost of the reform.

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A List of estimation moments

The following is the list of moments of the joint distribution of savings, labor force participation and sector choices used to fit the model to the data. They correspond to information on the estimation sample in year 2006.

1-3: Fraction of married couples with under 3 million in private savings (age 35-54,45-55,55-65)
4-6: Fraction of married couples with over 6 million in private savings (age 35-54,5-55,55-65)
7-9: Fraction of single males with under 3 million in private savings (age 35-54,45-55,55-65)
10-12: Fraction of single males with over 6 million in private savings (age 35-54,45-55,55-65)
13-15: Fraction of single females with under 3 million in private savings (age 35-54,45-55,55-65)
16-18: Fraction of single females with over 6 million in private savings (age 35-54,45-55,55-65)
19-21: Fraction of married couples with under 3 million total wealth (age 35-45, 45-55, 55-65)
22-24: Fraction of married couples with over 12 million total wealth (age 35-45, 45-55, 55-65)
25-27: Fraction of single males with under 3 million total wealth (age 35-45, 45-55, 55-65)
28-31: Fraction of single males with over 12 million total wealth (age 35-45, 45-55, 55-65)
32-33: Fraction of single males with under 3 million total wealth (age 35-45, 45-55, 55-65)
34-36: Fraction of single males with over 12 million total wealth (age 35-45, 45-55, 55-65)
37-40 : Fraction working - males (age 35-45,45-55,55-65,65-70)
41-44: Fraction working - married females (age 35-45,45-55,55-65,65-70)
45-48: Fraction working - married females (age 35-45,45-55,55-65,65-70)
49-51: Fraction in part-time work 35-45 - married females (age 35-45,45-55,55-65)
52-54: Fraction in part-time work 35-45 - single females (age 35-45,45-55,55-65)
55-58: Fraction in the Formal sector - males (No HS, HS dropout, HS graduate, College graduate)
59-62: Fraction in the Formal sector - females (No HS, HS dropout, HS graduate, College graduate)
63-68: Fraction males transiting from formal to Formal, formal to informal, informal to formal, informal to informal, inactive to formal, inactive to informal
69-74: Fraction males transiting from formal to Formal, formal to informal, informal to formal, informal to informal, inactive to formal, inactive to informal
75-77: Average annual earnings in Formal sector - males (No HS, HS dropout, HS graduate)
78-83: Average annual earnings, males (less than 5 years of labor market experience, 5-15 years, 15-25 years, 25-35 years, 35-45 years, 45-55 years)
84-86: Average annual earnings in Informal sector - males (No HS, HS dropout, HS graduate)
87-92: Average annual earnings in Informal sector - males (¡5 years experience, 5-15 years, 15-25 years, 25-35 years, 35-45 years, 45-55 years)
93-95: Average annual earnings in formal sector - females (No HS, HS dropout, HS graduate)
96-99: Average annual earnings in formal sector - females (¡5 years experience, 5-15 years, 15-25 years, 25-35 years)
100-102: Average annual earnings in informal sector - females (no HS, HS dropout, HS graduate)
103-106: Average annual earnings in informal sector - females (¡5 years experience, 5-15 years, 15-25 years, 25-35 years)
107: Fraction with under 1.5 million annual earnings - covered sector - males
108: Fraction with under 1.5 million annual earnings - uncovered sector - males
109 : Fraction with over 4.5 million annual earnings - covered sector - males
110 : Fraction with over 4.5 million annual earnings - uncovered sector - males
111: Fraction with under 1.5 million annual earnings - covered sector - females
112: Fraction with under 1.5 million annual earnings - uncovered sector - females
113: Fraction with over 4.5 million annual earnings - covered sector - females
114: Fraction with over 4.5 million annual earnings - uncovered sector - females
115: Average 1st difference in earnings - males (conditional on working at t and t-1)
116: Average 1st difference in earnings - females (conditional on working at t and t-1)
117-118: Fertility, females (married, single)
119-121: Fertility (no HS, HS dropout, HS graduate)
122-123: Fertility - married females (with one-two kid, with three-four kids)
124-125: Fertility - single females (with one-two kid, with three-four kids)
126-129: Fraction of break ups (age 35-45,45-55,55-65,65-75)
130-132: Fraction of break-ups (no HS, HS dropout, HS graduate)
133-135: Fraction of break-ups (Age difference¿=5 years, Age difference¡5 but ¿-5, Age difference¡=-5
136-139: Fraction working in the covered sector - males (35-45,45-55,55-65,65-70)
140-142: Fraction working in the covered sector - married females (35-45,45-55,55-65)
143-146: Fraction working in the covered sector - married females (35-45,45-55,55-65,65-70)
147-150: Fraction working, single females - no child (age 35-45,45-55,55-65)

151 Fraction working 35-45 - married females - two or more children LFP
152 Fraction working 45-55 - married females - two or more children LFP
153 Fraction working 55-65 - married females - two or more children LFP
154 Fraction working 65-70 - married females - two or more children LFP
155 Fraction working 35-45 - single females - two or more children LFP
156 Fraction working 45-55 - single females- two or more children LFP
157 Fraction working 55-65 - single females - two or more children LFP
158 Fraction working 65-70 - single females - two or more children LFP

B Exclusion Restrictions

Table B.1: **Exclusions: Households who contributed to the INP system**

variable	**mean**
Couples (%)	66.7
Single Women (%)	21.8
Single Men (%)	11.5
Lab. Force Part. (wom., %)	32.1
Lab. Force Part. (men, %)	60.9
Formal sector* (wom., %)	58.8
Formal sector* (men, %)	56.1
Age (men)	59.7
Age (wom.)	57.4
Schooling (men, years)	8.0
Schooling (wom., years)	7.9
Children	3.1

Source: Encuesta EPS, Superintendencia de Pensiones
* as a fraction of those working

Table B.2: **Exclusions: Households who contributed to the INP system**

variable	**mean**	**p10**	**p25**	**p50**	**p75**	**p90**
Annual Earnings (men, MM PS)	3.5	0.8	1.5	2.2	3.6	6.6
Annual Earnings (wom., MM PS)	2.5	0.6	1.1	1.8	2.6	5.2
Non-Pension assets** (MM PS)	16.5	0.0	4.0	9.7	18.0	35.0

Source: Encuesta EPS, Superintendencia de Pensiones
Note: MM PS = Million Pesos
** The top 2% of pension values were trimmed in calculating these statistics to avoid sensitivity to outliers in the data

Table B.3: **Exclusions: Individuals younger than 35 in 2004**

variable	**mean**
Couples (%)	48.6
Single Women (%)	24.2
Single Men (%)	27.2
Lab. Force Part. (wom., %)	51.6
Lab. Force Part. (men, %)	87.8
Formal sector* (wom., %)	73.0
Formal sector* (men, %)	71.4
Age (men)	30.2
Age (wom.)	28.5
Schooling (men, years)	11.4
Schooling (wom., years)	11.7
Children	1.0

Source: Encuesta EPS, Superintendencia de Pensiones
* as a fraction of those working

Table B.4: **Exclusions: Individuals younger than 35 in 2004**

variable	**mean**	**p10**	**p25**	**p50**	**p75**	**p90**
Annual Earnings (wom., MM PS)	2.4	0.6	1.2	1.8	3.0	4.5
Annual Earnings (men, MM PS)	3.2	1.2	1.6	2.4	3.6	5.5
Non-Pension assets** (MM PS)	8.9	-0.1	0.3	4.8	11.9	20.9
Pension assets** (wom., MM PS)	1.8	0.0	0.0	0.0	0.3	1.8
Pension assets** (men, MM PS)	7.0	0.0	0.2	1.1	3.0	6.0

Source: Encuesta EPS, Superintendencia de Pensiones
Note: MM PS = Million Pesos
** The top 2% of pension values were trimmed in calculating these statistics to avoid sensitivity to outliers in the data

Table B.5: **Exclusions: Individuals who remarried after the age of 35**

variable	**mean**
Couples (%)	59.7
Single Women (%)	26.9
Single Men (%)	13.5
Lab. Force Part. (wom., %)	38.2
Lab. Force Part. (men, %)	70.1
Formal sector* (wom., %)	64.6
Formal sector* (men, %)	55.6
Age (men)	54.8
Age (wom.)	52.0
Schooling (men, years)	8.3
Schooling (wom., years)	8.1
Children	2.7

Source: Encuesta EPS, Superintendencia de Pensiones
* as a fraction of those working

Table B.6: **Exclusions: Individuals who remarried after the age of 35**

variable	**mean**	**p10**	**p25**	**p50**	**p75**	**p90**
Annual Earnings (wom., MM PS)	3.4	0.5	1.0	1.7	3.6	6.0
Annual Earnings (men, MM PS)	7.9	0.7	1.4	2.0	3.6	6.6
Non-Pension assets** (MM PS)	12.7	0.0	1.9	5.1	15.0	29.7
Pension assets** (wom., MM PS)	2.7	0.0	0.0	0.0	0.8	5.7
Pension assets** (men, MM PS)	11.5	0.0	0.0	2.4	7.7	17.7

Source: Encuesta EPS, Superintendencia de Pensiones
Note: MM PS = Million Pesos
** The top 2% of pension values were trimmed in calculating these statistics to avoid sensitivity to outliers in the data

Table B.7: **Exclusions: Inconsistent or missing answers**

variable	**mean**
Couples (%)	71.2
Single Women (%)	18.8
Single Men (%)	10.0
Lab. Force Part. (wom., %)	47.0
Lab. Force Part. (men, %)	81.2
Formal sector* (wom., %)	60.0
Formal sector* (men, %)	61.7
Age (men)	49.4
Age (wom.)	48.6
Schooling (men, years)	10.0
Schooling (wom., years)	9.9
Children	2.9

Source: Encuesta EPS, Superintendencia de Pensiones
* as a fraction of those working

Table B.8: **Exclusions: Inconsistent or missing answers**

variable	**mean**	**p10**	**p25**	**p50**	**p75**	**p90**
Annual Earnings (wom., MM PS)	3.5	0.6	1.2	1.9	4.2	6.1
Annual Earnings (men, MM PS)	7.0	1.3	1.8	3.0	4.8	9.6
Non-Pension assets** (MM PS)	14.5	0.0	3.0	6.9	16.2	30.5
Pension assets** (wom., MM PS)	2.6	0.0	0.0	0.0	0.5	4.1
Pension assets** (men, MM PS)	13.2	0.0	0.4	4.2	10.7	26.7

Source: Encuesta EPS, Superintendencia de Pensiones
Note: MM PS = Million Pesos
** The top 2% of pension values were trimmed in calculating these statistics to avoid sensitivity to outliers in the data

C Parameter Estimates

Table C.1: Probability of no pregnancy: logistic regression

	Coef.	**Std. Err.**	**z**
married	-0.92086***	0.241469	-3.81
number of kids	-0.78756***	0.085428	-9.22
married*kids	0.302895***	0.092842	3.26
schooling	-0.05482***	0.01195	-4.59
age	0.149925***	0.011537	13
constant	0.449574	0.478111	0.94

Table C.2: Simulated Method of Moments Estimates

Name	**Symbol**	**Estimate**	***Std. errors***	**z**
CRRA coefficient	σ	-0.5755***	*0.0198*	-29.0286
Marginal utility of consumption coefficients:				
Stock of children (female)	ν_0^f	0.2750***	*0.0665*	4.1375
Stock of children (male)	ν_0^m	0.8734***	*0.0633*	13.7912
Leisure (female)	ν_1^f	1.6336***	*0.2487*	6.5686
Leisure (male)	ν_1^m	0.9219***	*0.1620*	5.6907
Utility from staying at home				
female, type 1	δ_l^f	0.0725***	*0.0144*	5.0204
female, type 2	δ_l^f	0.2225***	*0.0371*	5.9927
male, type 1	δ_l^m	-0.0280**	*0.0121*	-2.3178
male, type 2	δ_l^m	-0.0355***	*0.0093*	-3.8372
Utility of part-time work (female)	δ_p^f	0.4992***	*0.0411*	12.1562
Log Income coefficients (Formal sector, male):				
Constant (type 1)	θ_{0C}^m	-0.2138***	*0.0724*	-2.9509
Constant (type 2)	θ_{0C}^m	-0.2825**	*0.1110*	-2.5447
Schooling	θ_{1C}^m	0.1100***	*0.0080*	13.7818
Experience	θ_{2C}^m	0.0320***	*0.0057*	5.6262
Experience squared	θ_{3C}^m	-0.0006***	*0.0001*	-4.8938
Log Income coefficients (Informal sector, male):				
Constant (type 1)	θ_{0U}^m	-0.6252***	*0.1945*	-3.2142
Constant (type 2)	θ_{0U}^m	-0.1839*	*0.0969*	-1.8986
Schooling	θ_{1U}^m	-0.0075	*0.0062*	-1.2084
Experience	θ_{2U}^m	0.0200***	*0.0048*	4.1708
Experience squared	θ_{3U}^m	0.0001	*0.0001*	0.7821
Log Income coefficients (Formal sector, female):				
Constant (type 1)	θ_{0C}^f	-0.4509***	*0.1017*	-4.4355
Constant (type 2)	θ_{0C}^f	-0.4784**	*0.2042*	-2.3432
Schooling	θ_{1C}^f	0.0980***	*0.0094*	10.4468
Experience	θ_{2C}^f	0.0423***	*0.0086*	4.9384
Experience squared	θ_{3C}^f	-0.0008***	*0.0003*	-2.7306
Log Income coefficients (Informal sector, female):				
Constant (type 1)	θ_{0U}^f	-0.3125***	*0.0983*	-3.1792
Constant (type 2)	θ_{0U}^f	-0.6488***	*0.2945*	-2.2026
Schooling	θ_{1U}^f	0.0000	*0.0009*	0.0000
Experience	θ_{2U}^f	0.0400***	*0.0086*	4.6626
Experience squared	θ_{3U}^f	-0.0005*	*0.0003*	-1.7201
Probability of no separation coefficients				
Constant	π_0	-5.2075***	*0.1519*	-34.2915
Age of the husband	π_1	0.0274***	*0.0009*	30.2029
Schooling	π_2	0.0278***	*0.0008*	37.0225
Age difference	π_3	0.0017***	*0.0001*	14.0455
Switching costs				
Between sectors (male)	δ_s^m	0.0085***	*0.0017*	5.0223
Between sectors (female)	δ_s^f	0.0040***	*0.0005*	7.8330
Returning to work (male)	δ_w^m	0.6735***	*0.0729*	9.2444
Returning to work (female)	δ_f^f	0.6704***	*0.0692*	9.6889
Type logit coefficients				
Constant	ρ_0	0.1000	*0.0796*	1.2562
Schooling (female)	ρ_s^f	0.0134	*0.0086*	1.5590
Schooling (male)	ρ_s^m	-0.0035	*0.0039*	-0.8920
Shock variances				
Earnings (male, covered sector)	σ_C^m	0.1950***	*0.0442*	4.4158
Earnings (male, uncovered sector)	σ_U^m	0.5812***	*0.1119*	5.1942
Earnings (female, covered sector)	σ_C^f	0.2200***	*0.0528*	4.1687
Earnings (female, uncovered sector)	σ_U^f	0.6758***	*0.1525*	4.4321
Utility of staying home (male)	σ_H^m	0.1530***	*0.0284*	5.3819
Utility of staying home (female)	σ_H^f	0.2663***	*0.0419*	6.3600