Heterogeneous Effects of Social Insurance: Empirical evidence from Chile *

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Abstract

This study examines the impact of pension subsidies in Chile's defined contribution pension system using longitudinal and survey data. Employing a difference-in-differences approach, significant negative effects on retirement savings were observed for workers expected to benefit the most from the reform. The life-cycle model explains the crowding out of pension assets, with disincentive effects smaller than anticipated. Financially illiterate treated workers drive an underestimation because show more passive responses to subsidies. This sheds light on the complexities of pension subsidies and offers valuable information for policymakers analyzing their fiscal cost with a life-cycle model.

Keywords: retirement, saving, informality, hyperbolic discounting

JEL: D14, G11, J26

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1 Introduction

In a 1997 U.S. Congress hearing (Kay, 1997) the Representative of Florida praises the Chilean pension system, proposing a privatization of U.S. Social Security. The specific policy proposal is presented by the executive director of a non-governmental organization. The policy proposal mandates workers to save part of their payroll taxes into a personal retirement account to "allow the moderate- to low-income workers of this country to save money for their own retirements". Since then, we have seen a partial privatization that is reflected on defined contribution (DC) pension plans growing faster than defined benefits (DB) plans.[1] This shift in policy places people in charge of their financial security after retirement (Lusardi, 2008). In a pension system that relies more heavily on private savings, workers' pensions are exposed to endogenous and exogenous factors, such as returns on capital investments (Feldstein, 1974), workers' financial literacy (Lusardi and Mitchelli, 2007), psychological biases related to under saving (Laibson, 1997), aggregated labor market risk that can affect generations heterogeneously (Allen and Gale, 1997), health risk (Rust and Phelan, 1997) and longevity (Fong et al., 2011). Under this system, workers face poverty in retirement if they do not accumulate enough savings to fund their needs when they leave the labor market (Poterba et al., 2007). In this paper, I study Chile's case, where there was a full generational transition to a fully funded DC system.[2] I study the 2008 reform which established pension subsidies that benefited the working population heterogeneously depending on their accumulated pension wealth at retirement. Studying this case allows me to conduct different empirical tests of the crowding out effect of pension subsidies on retirement savings, combining causal inference methods and microeconomic theories.

In the traditional framework of Feldstein (1974), a dollar of pension subsidies reduces retirement savings in one dollar (e.g. crowding out effect). Empirically, estimated elasticities are approximately a half. Blau (2016) explains this empirical fact using a simulated life-cycle model that incorporates employment decisions, a bequest motive, and other assumptions. These results are key in terms of the design of a pension system in Feldstein (1985) theoretical framework. Feldstein argues that the optimal level of social insurance during retirement depends on the trade-offs of offering social protection to ex-post poor retirees. The cost of offering these benefits include fiscal costs and

[1] Roxburgh (2011), in a McKinsey & Company report, estimated that the top 7 DB plans represented 70% of pensions assets, and they expected that this number reaches 50% by 2018.

[2] Empirically, it has been documented that countries that rely mostly on private savings tend to have higher old-age poverty rates (Börsch-Supan et al., 2016).

distortions generated by introducing implicit taxes on private savings and earned income. Currently, half of OECD countries offer pension subdies to raise (ex-post) poor retirees' welfare. I argue that countries' policy designs reflect societal concerns over fairness and redistribution, considering the expected distortions in labor and saving markets, as highlighted in Saez and Stantcheva (2016) welfare analysis of the income tax.[3] In light of these considerations, understanding the welfare effects of full or partial privatization of U.S. social security, as well as its predicted impact on wealth accumulation and financial and labor market decisions, necessitates a solid theoretical foundation.

By combining surveys and a comprehensive administrative panel dataset of workers from Chile, this study employs a difference-in-differences (DiD) regression to assess the disincentive effects on formal labor market participation following the pension reform. Specifically, the analysis focuses on the effects of the reform, which was implemented in July 2008 and introduced pension subsidies based on accumulated pension assets at retirement. To identify the treatment and control groups, a well-defined assignment strategy is employed for workers. Following Engelhardt and Kumar (2011), I simulate workers' expected pension subsidies based on accumulated assets at retirement, following the reform rules. I sort workers using pre-2007 data and assign them to treated or control group (first and third terciles, respectively). The analysis shows that workers expecting higher benefits reduced mandatory retirement savings after the reform. I validate my identification strategy showing that the effect is not driven by a negative trend of treated workers' propensity to save for retirement before the reform. Second, to test for heterogenous effects, I conduct a DiD with continuous treatment, finding mixed effects. In this case, when I restrict the sample to the treated groups. The analysis suggest ambiguous effects of the reform. Specifically, my findings indicate that after the reform, treated workers, based on average earnings to the poverty line (or fraction of time with contributions), experience varying effects on their probability to contribute to the pension system, contingent on the regression specification or sample selection. These results suggest the presence of bias from heterogeneous treatment effects. Thirdly, to address the potential bias arising from heterogeneous treatment effects, I draw inspiration from Chetty et al. (2014) examination of active versus passive responses in the Danish reform. Subsequently, I conduct a test to assess the differential effect along the financial literacy margin within a subsample of workers who participated in the 2006 Social Protection Survey (EPS). To measure financial literacy, I construct an index based on three

[3] The benefits are related to redistribution within and between generations (Tyrowicz et al., 2018).

questions proposed by Lusardi and Mitchell (2011). The primary finding of this analysis highlights a notable degree of heterogeneity in workers' responses to the reform, which is masked by the baseline DiD approach. To delve deeper, I employ the non-parametric cross-sectional method developed by Cattaneo and Jansson (2018) and show that the probability of participation in the pension system post-reform declined more significantly among workers with financial incentives and higher financial literacy.

My findings have significant implications for social welfare analysis. Overestimating disincentive effects from a pension reform could affect the generosity of social security programs. A 10-percentage-point reduction in workers' propensity to contribute to the pension system leads to a \$0.15 decrease in accumulated pension assets at retirement for every \$1 in subsidies. Incorporating rational and behavioral factors into a life-cycle model can improve the understanding and approximation of government expenditure on pension subsidies. This aids in crafting more effective and equitable social security programs.

I make three significant contributions to the literature. Firstly, I introduce new publicly available survey and administrative panel data to empirically analyze the retirement saving effects of an innovative social security reform in Chile. This study complements existing works like Joubert (2015) and Garcia et al. (2015), which estimate the effect of the same reform using structural models. The empirical design is grounded in traditional life-cycle models, such as Feldstein (1974), which predict that social insurance discourages savings as workers tend to consume rather than save for retirement. My findings support Feldstein's prediction, revealing that new pension subsidies are associated with a lower propensity to save in individual retirement accounts. However, I provide new evidence that suggests pension subsidies do not generate a one-to-one crowding out effect on pension assets. Secondly, I explore heterogeneous treatment effects and find no gender differences. I also identify weak evidence indicating that young workers reduced their propensity to contribute more than middle-aged and older workers. Moreover, among workers benefiting from the policy, less (more) financially literate individuals experience smaller (larger) reductions in their propensity to contribute to the pension system. This observation aligns with the findings of Chetty et al. (2014) in their analysis of active or passive responses to a pension reform in Denmark. Thirdly, I add to the literature by exploring the impact of distortions in labor markets and behavioral biases on the welfare analysis proposed by Saez and Stantcheva (2016). My life-cycle model considers heterogeneity in workers' preferences, including factors like health shocks, and is able to adjust a complementarity between leisure and home production, or workers' bequest motive that affect the utility of wealth at retirement. Additionally, the model incorporates hyperbolic discounting, a type of irrationality that generates present bias and dynamic inconsistency (Laibson, 1997). This unique analysis allows me to disentangle the effects of both rational and irrational factors in explaining the empirically estimated effects of the reform. This approach differentiates itself from studies focusing solely on information frictions when governments set retirement age (Seibold, 2021). Finally, my research contributes valuable insights to the study of the Chilean pension system, offering lessons on the effects of pension reforms in countries like the U.S., where debates on social security are politically contentious due to its widespread popularity.

The paper proceeds as follows: Section 2 provides background information about the Chilean Pension System and its recent reforms. Section 3 reviews the literature. Section 4 describes a theory on retirement saving behavior to understand the reduced form empircal estimates. Section 6 describes the dataset, key variables used in the study, and presents summary statistics. Section 5 explains the empirical method. Section 7 presents the results. Section 8 interprets the results through a policy lens. Section 9 concludes.

2 Background

In 1981, Chile adopted a universal fully funded defined contribution (DC) system, equivalent to 401(k) or 403(b) programs in the U.S. The system consists of a mandatory lifetime savings plan with retirement contributions equaling to 10% from wage incomes for full-time employees.[4] The pensions at retirement are calculated from accumulated pension assets, that include returns on contributions, and life expectancies by gender that enter in the actuarial calculations. In Chile, retirement ages are 65 for men and age 60 for women. At retirement age, workers have the option to use their accumulated pension assets to purchase a life annuity in a centralized auction, or stay in a withdrawal plan that pay a pension that is based on a regulated interest rate. This interest rate intends to capture the long term return of pension funds, and is periodically updated by the Chilean Superintendency of Pensions.[5] The Chilean system has been criticized for its low levels of

[4]The posibility to stay in the old pay-as-you-go (PAYGO) system expired in 1986.

[5]In a recent paper, Aryal et al., 2020 analyze the observed choices in the Chilean life annuity market.

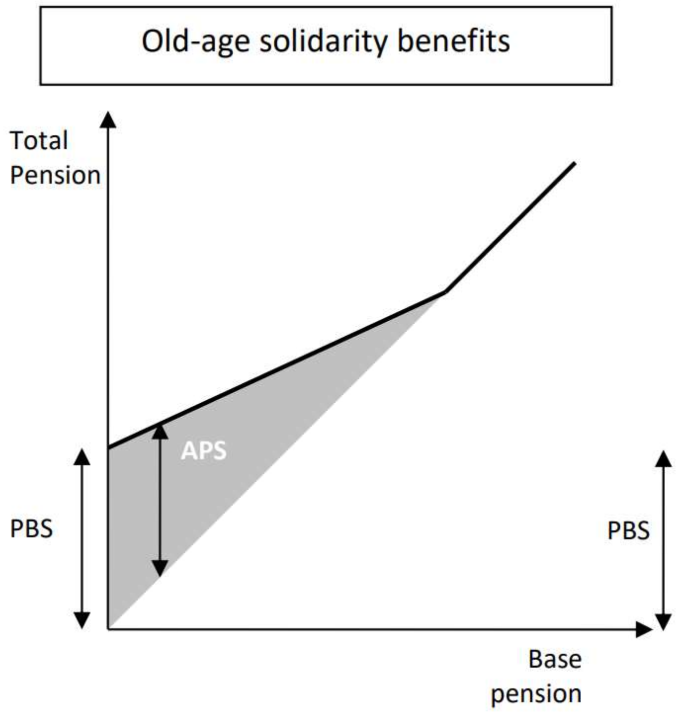
retirement savings among lower-income, unemployed, and self-employed households (De Mesa and Montecinos, 1999). One year before the reform, the average monthly retirement payment of the scheduled withdrawal plan is 70% of the minimum wage, the typical option of low-income worker (Mitchell and Ruiz, 2009). Before the reform, the system had two redistributive pillars for poor retirees. First, the government offered a means-tested welfare pension of 1/3 of the minimum wage. Second, the government offered a minimum pension guarantee for workers with at least 240 months of contributions, and that are not able to finance a pension of two thirds of the minimum wage. However, Berstein et al. (2005) analyze the eligibility to pension subsidies. The authors show that the requirement of being a retiree with a household income per capita below the 40th percentile of the population limited the access to the welfare pension. The authors also show that the minimum number of monthly contributions limited the access to the guarantee.

To counteract low expected pensions, in July of 2008, the Chilean government implemented a major pension reform, which consisted of two key components as is described in Figure 1. First, the government rolled out a minimum pension program under which every citizen that belongs to the 60% poorest fraction of the population (based on household income per capita) is eligible for a minimum pension upon retirement *(Pension Basica Solidaria [PBS])*.[6] By 2011, the minimum pension is set at 41% of the minimum wage. Second, the reform also introduced a pension top-up benefit *(Aporte Previsional Solidario [APS])*, which provides additional support to individuals whose pension levels are less than the maximum pension eligible for pension top-up benefit *(Pensión Máxima con Aporte Solidario [PMAS])* that in 2011 is set at 140% of the minimum wage.[7]

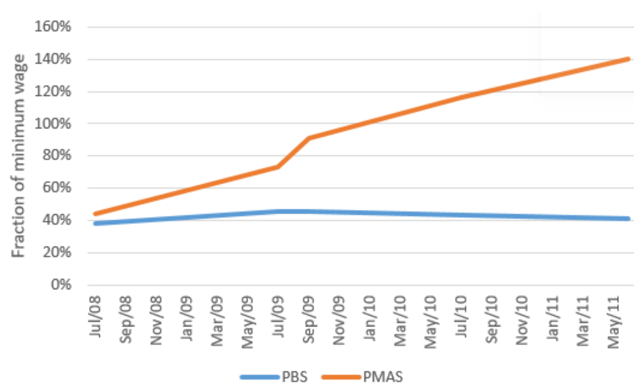
By early 2022 a 66% of retirees receives a subsidized pension. Since the reform started, the Chilean pension policy has moved towards increasing the generosity of the system, adjusting its two main parameters that are the minimum pension (PBS) and the maximum pension eligible to receive pension subsidies (PMAS). The evolution of these parameters is presented in Figure 1.

[6] In order to be specific, eligibility is determined from the pension targeting score ("puntaje de focalización previsional") that use administrative records of retirees' capital and property income, imputed income and self-reported information to establish it.

[7] In 2006 the Chilean Budget Office estimated that annual subsidies implied by the pension reform at 1.1% of GDP.



(a) Pension subsidies diagram



(b) Pension reform's parameters

Figure 1: 2008 pension reform rules

In Panel (a), a diagram of the pension subsidies introduced by the pension reform is presented. We can distinguish two types of benefits. A minimum pension (PBS), a benefit that is provided to all individuals that cannot self financed a pension. The shaded area, measures the income supplement for pensioners (APS). The income suplement targets only workers that have pensions below a level pre-defined by law (PMAS). Source: Chilean Superintendency of Pensions. In Panel (b) the evolution of the minimum pension (PBS) and the maximum pension eligible for the pension top-up benefit (PMAS) for time frame of study is presented.

3 Literature

There is new work examining the debate over the negative relationship between unfunded pension benefits and the accumulation of retirement savings, and its effect on labor supply.[8] Specifically, I contribute to the debate on social security wealth substitutability through the examination of Chile's pension system that used to have a very limited access to pension subsidies, and suddenly introduces a universal minimum pension program. I use a long publicly available administrative panel dataset that allows me to follow workers' retirement saving behavior before the Chilean minimum pension reform is implemented in mid-2008. The main advantage of the proposed empirical setting is the simplicity to identify (ex-ante) groups of workers that would benefited differently by the pension subsidies. Secondly, I contribute to the study of how behavioral biases can amplify or limit the impact of social security retirement benefits on workers' decisions. From a theoretical perspective, I show that a life-cycle model where workers experience a discontinuity on the marginal utility of consumption, before and after retirement, and suffer from present bias, can explain how pension subsidies crowd out pension assets in this reform. On the empirical side, I provide evidence that gives support to microeconomic theory that predicts that pension subsidies create an implicit tax on low-income workers' retirement savings. However, my empirical results show evidence of heterogeneous treatment effects along workers' financial literacy. This is, I find that workers with the incentives to reduce their propensity to save for retirement and that also have higher levels of financial literacy, have higher probabilities of opting-out from the pension system after the reform. Third, I contribute to the study of the Chilean pension system, a fully funded defined contribution scheme that has been running since the early 1980s. This paper expects to provide a quantitative guidance regarding wealth substitutability and informality for other countries that seek to quantify the fiscal costs of pension policy design.

Early studies investigating the relationship between social security and savings utilized time series analysis, yielding varied conclusions. Feldstein (1974) reported a negative effect, while Barro et al. (1979) found no significant impact of U.S. social security on capital accumulation. Later, in a cross-country analysis conducted by Feldstein (1980), he observed a significant reduction in private savings due to U.S. social security. From a microeconometric perspective, Feldstein and Pellechio

[8] This debate can be dated to Feldstein (1974) and Barro et al. (1979).

(1979) estimated that \$1 of unfunded pension wealth reduced other asset accumulation by roughly \$0.93. Similarly, Kotlikoff (1979) found a \$0.66 reduction in net worth for every \$1 increase in social security wealth. On the other hand, using U.S. longitudinal administrative data, David and Menchik (1985) found no relationship between U.S. social security wealth and age-wealth profiles. Bernheim and Levin (1989) analyzed microdata on expected social security benefits, revealing that social security benefits crowded out personal savings of single individuals on a dollar-for-dollar basis, but had no effects on couples. Thus, until the late 1980s, there was no clear consensus on the effects of social security on saving incentives or labor choices. More recent studies have used causal inference methods to examine the impact of U.S. social security on labor supply. Krueger and Pischke (1992) found a very small effect, exploiting exogenous variation on social security wealth from the 1977 amendments to the Social Security Act. . Attanasio and Brugiavini (2003) and Attanasio and Rohwedder (2003) used cohort and age groups as instruments to study pension wealth. Their results implied a negative relationship between social security wealth and workers' retirement saving rates. Engelhardt and Kumar (2011) took a different approach, constructing an instrumental variable using microdata on U.S. workers' perceived pension wealth, administrative data on workers' occupational pension plans, and estimates of their social security wealth. They estimated that \$1 of pension wealth reduced net worth by \$0.53 to \$0.67, with crowding out more pronounced at higher levels of non-pension wealth. International studies have also explored this topic. Aguila (2011) found no evidence of increased savings after the transition from a DB to DC system in Mexico. Kaushal (2014) documented a modest negative effect on employment due to the expansion of India's National Old Age Pension Scheme. Lehmann-Hasemeyer and Streb (2018), using nineteenth-century county-level data from Germany, estimated that Bismarck's social insurance system crowded out household savings by 15 percent of a worker's annual income.

This study is associated to other papers that explain retirement related behavior from labor market distortions. Gustman and Steinmeier (1983) show evidence that is consistent with the existence of a lower limit constraint on hours of work. This difficulty to adjust hours of work can affect retirement decisions, and the labor supply of workers that approach their retirement age. Theoretically, Fields (2009) analyzes the labor market as a segmented one. In the proposed framework, poor workers are selected out of the formal market, clustering into the type of "casual jobs" described by Lewis (1954). To the extent that labor markets are segmented, I expect little to no effect from the introduction of pension subsidies. The empirical results documented in this paper reject this hypothesis, and favors Maloney (1999) that suggests that participation in informal labor markets is a decision, which depends on workers' labor market opportunities and other incentives generated by the government.[9] Theoretically, Meghir et al. (2015) also show that the size of the informal labor market depends on government's effort to enforce formalization (e.g. increasing the cost of informal hiring).

This paper relates to the behavioral economics literature that use hyperbolic discounting preferences or discontinuities in the marginal utility of consumption at retirement as frictions to explain labor market decisions. Laibson et al. (1998) show how the hyperbolic discounting assumption helps better explain the empirical evidence on low saving rates for retirement among the young population, the popularity of social security among the low-income, the provision of employer-based pension plans, the percentage of households that live close to their credit limit, and the feeling of regret about retirement with no savings among the old.[10] Banks et al. (1998) and Bernheim et al. (2001) find that large consumption drops observed at retirement can be also explained by hyperbolic discounting. DellaVigna and Paserman (2005) show empirical evidence that favors the idea that individuals with measured hyperbolic time preferences would tend to leave for another job less often and put less effort into finding a job when they are unemployed. Schwarz and Sheshinski (2007) conduct retirement policy analysis under hyperbolic time preferences, they theoretically show that a pay-as-you-go (PAYGO) system is preferable to a fully funded system. My theoretical analysis suggests that discontinuities in the marginal utility of consumption at retirement and hyperbolic discounting preference can both help to explain the effects of the reform. On the other hand, my results relate to the literature on financial literacy as an important factor to explain the propensity to save for retirement (Lusardi and Mitchell, 2007).[11] My empirical results are consistent with the evidence of passive versus active responses in the pension reform analyzed by Chetty et al. (2014). I find that my estimated crowding out effects are concentrated on workers with more incentives to opt-out from the pension system and that are more financially literate. This finding is also consistent with the theoretical association proposed by Love and Phelan (2015) between hyperbolic

[9]Maloney (1999) findings are explained by the theoretical models proposed by Bosch and Esteban-Pretel (2012) and Bosch and Esteban-Pretel (2015).

[10]Hyperbolic discounting is subsumed by the time-inconsistency plans early proposed by Strotz (1955) and Pollak (1968).

[11]Behrman et al. (2012) study financial literacy in Chile using the same survey data.

discounting preference and the behavior of less financially educated workers.

Finally, I contribute to the economic literature that studies the Chilean pension system, the first country in the world that privatized its PAYGO system in 1980. Specifically, I provide empirical evidence and a theoretical framework that can be used to quantify the fiscal cost of pension subsidies when conducting pension policy design in systems where DC and DB pension systems coexist. The literature on the Chilean case, starts with Diamond (1993) who criticizes the Chilean pension system because of its relatively high administrative costs (e.g. high management fees) and low levels of redistribution. Corsetti and Schmidt-Hebbel (1997) show theoretically and empirically that the Chilean reform increased the national saving rate and boost long-term economic growth.[12] Edwards et al. (1998) describes the transition towards the private system, focusing on the benefits on capital market development. Since the reform, other authors have analyzed the effects of the 2008 Chilean pension reform on workers' propensity to save for retirement. For example, Joubert (2015) and Garcia et al. (2015) both conducted ex-ante simulations of the effects of the pension reform using structural models, they predict that the reform would reduce labor supply and reduce the formalization among the poor. Attanasio et al. (2011) conduct an empirical analysis using a two stage estimation that endogenously connects pension wealth and formal labor supply. Their analysis suggests a small reduction in the propensity to contribute to the pension system. Using the same method, Lopez Garcia and Otero (2017) find evidence of an increase in workers probability of working formally, and only a small negative effect on female workers' labor supply. More recently, Troncoso (2022) propose a DiD estimator where he compares old workers in the bottom 60% of income distribution that are expected to benefit from the pension reform. His empirical design assigns workers of the same age that are former military personnel to the control group, which cannot benefit from the new pension subsidies. The author finds that the reform would have increased labor force participation and hours of work for men. As we can see, this paper can be seen as the first one in estimating a significant reduction, although heterogeneous, on the propensity to contribute to the pension system because of the reform. This paper intends to contribute to the theoretical and empirical literature that analyze this pension reform. For example, Berstein et al.

[12]This result contradicts the models that show that PAYGO or fully funded system are welfare equivalent (see Lindbeck and Persson (2003) for a review on this topic). In the absence of behavioral economic factors, fully funded DC system maximize societal welfare if there are positive externalities in capital formation, which causes that forcing workers to save for retirement and participate in capital markets can benefit society as a whole.

(2013) theoretically study that workers that can expect to benefit from the pension subsidies also have incentives to migrate to higher risk pension funds. Behrman et al. (2011) estimate that targeted poor households received roughly 2.4 percent more household annual income, higher expenditures on healthcare, more leisure hours, and improved self-reported health. Miglino et al. (2022) find a reduction of 2.7 percentage point in the probability of dying around the minimum pension cut-off, suggesting that the effect could be explained by an increase in food consumption and visits to health centers.

4 Theory

In this section, I outline the theoretical model that describes labor market and saving decision making process of Chilean workers.

Workers

Workers are classified with respect to gender (G), age (A) and educational level (e). By assumption workers take decisions based on their expected discounted utility in a dynamic fashion:

$$V_t = \max_{C_t, L_t, h_t^f} \quad U(C_t) + \sum_{j=t+1}^{T-1} \beta_{t,j} \, E[U(C_j)] + \theta \beta_{t,T} F(W_T^P, W_T, r_T^*) \tag{1}$$

$$W_{t+1}^P = \left(W_t^P + \kappa_t \left(h_t^f\right)\right)(1 + r^*)$$
$$W_{t+1} = \left(W_t + y_t \left(h_t^f\right) - C_t - \varsigma_t \left(h_t^f\right)\right)(1 + r) - \varepsilon_{t+1} \left(h_t^f\right)$$

C_t is worker's consumption at time t; $h_{f,t}$ is the fraction of time worked in the formal market at time t; $\beta_{t,t+j}$ measures worker's subjective discount factor from time t to $t+j$; $U(\not\,)$ is a von-Neumann Morgenster utility function defined on consumption; θ is the weight that worker's assign to their expected utility at retirement; $F(W_T^P, W_T, q, r^*)$ is a utility function that measures workers' welfare at an exogenously defined retirement age (T), at which worker's welfare is a function of worker's pension that is calculated from the sum of pension assets (W_T^P) plus other assets (W_T). The pension is calculated from the cost of an annuity that depends on mortality risk at retirement (q) and the return of pension assets (r^*); $y_t \left(h_t^f\right)$ is worker's earned income, as a function of the fraction of time worked in formal markets at time t[13]; $\varsigma_t\left(h_t^f\right)$ aggregates social security contributions that are a function of formal earned income. Social security contributions include a tax to finance the public health fund ($\mathit{\Delta}_t$), and κ_t mandatory retirement savings at time t; r^* and r correspond to the of pension assets and other assets; $\varepsilon_{\theta,t+1}\left(h_t^f\right)$ is the out-of-pocket medical costs implied by a health shock at time $t+1$, which is also dependent on formal earned income.

Public Health, Retirement and Social Security

In the model, employees in the formal sector make social security contributions. Social security contributions have two components, a health pillar that mandates a contribution to the public health plan (θ). The public health fund is the most popular option for the low-income households in Chile as is calculated by (Pardo and Sabat, 2023). A pension pillar, where a τ mandatory saving rate is fixed by the government. The following equation aggregates social security contributions as a function of the time worked in the formal market, such that:

$$\varsigma_t(h_t^f) = \mathit{\Delta}_t\left(h_t^f\right) + \kappa_t\left(h_t^f\right) = min\left\{y_t^F\left(h_t^f\right)\theta, \bar{y}\theta\right\} + min\left\{y_t^F\left(h_t^f\right)\tau, \bar{y}\tau\right\}$$

$\varsigma_t(h_t^f)$ measures annual social security contributions; $\kappa_t\left(h_t^f\right)$ are mandatory savings given a fraction of time devoted to work in the formal sector (h_t^f); $\mathit{\Delta}_t\left(h_t^f\right)$ are mandatory contributions to the public health fund at time t, $\bar{y}$ is the maximum taxable income level.

Social security benefits are related to labor market and saving decisions through two mechanisms. First, future health copayments are based on formal income. The workers that do not participate in the formal labor market, or earn the minimum wage, face a copayment of zero. Workers that earn a formal salary that is between the minimum wage (y_l) and the threshold (y_m) face a copayment equals to ε_l. Higher income workers face a copayment that equals to ε_m. Mathematically, I can

[13]Earned income is added to non-pension wealth (W_t), and is the sum of y_t^F and y_t^I that correspond to formal and informal income, respectively.

write out-of-pocket medical expenses as a function of formal earned income as follows:

$$\varepsilon_{t+1}(h_t^f) = \begin{cases} 0 & y_t^F \leq y_l \\ \varepsilon_l & y_l < y_t^F \leq y_m \\ \varepsilon_m & y_t^F > y_m \end{cases}$$

Second, after the reform the pensions of workers are affected by the rules set by the pension reform, such that:

$$F(W_T^P, W_T, r^*) = \begin{cases} \left(p_l + \frac{p_l}{p_m}\frac{W_T^P}{a(r^*)} + \frac{W_T}{a(r^*)}\right)^v & 0 < \frac{W_T^P}{a(r^*)} \leq p_m \\ \left(\frac{W_T^P}{a(r^*)} + \frac{W_T}{a(r^*)}\right)^v & \frac{W_T^P}{a(r^*)} > p_m \end{cases}$$

p_l is the minimum pension established by design; p_m is the maximum pension threshold allowed to receive the pension top-up benefit; $a(r^*)$ is the cost of an annuity that pays one unit of pension per period while the retiree is alive, which is a function of the return of pension assets (r^*); the parameter v controls the marginal utility of a pension.[14]

Labor Market

In the model, earned income is a function of time worked in formal (h_t^f) and informal markets ($1 - h_t^f$), as follows:

$$y_t = y_t^F + y_t^I = w_f(A, e)h_t^f + \Delta w_f(A, e)(1 - h_t^f)$$

$w_f(A, e)$ is the exogenously defined formal wage as a function of age (A) and education (e); Δ measures a penalty for working in the informal labor market.[15] The wedge between formal and informal market wages is taken exogenously to abstract from general equilibrium effects that can be analyzed independently.

[14]The idea of introducing a wedge between the marginal utility of consumption during worker's active life (γ) and at retirement's (v) can be seen as an approximation to a more complex mechanism driven by the complementarity between leisure and home production suggested by Moran et al. (2021), or a marginal utility of consumption that depends on health status (Ameriks et al., 2020).

[15]El Badaoui et al. (2008) provides empirical evidence for this penalty from an emerging economy.

Preferences

Time preferences are assumed exponential or hyperbolic as in Laibson (1997), such that:

$$\beta_{t,t+j} = \bar{\beta}\delta^{t+j}$$

$\beta_{t,t+j}$ is the discount factor for the period that goes from t and $t+j$, where j is the number of periods ahead; $\bar{\beta}$ is a constant discounting parameter and δ^{t+j} allows for a differential treatment of utility flows received in the short versus term long term. This assumption is motivated by the theoretical analysis of Montiel Olea and Strzalecki (2014), they offer an explanation on how this time preference assumption disentangles discounting from the elasticity of intertemporal substitution.
In the model, during worker's active life they derive utility from consumption, as follows:

$$U(C_t, L_t) = C_t^{\gamma}$$

where γ determine worker's marginal utility over consumption.

I distinguish three stages of life, retirement (65+ male; 60+ female), pre-retirement (45-65 male; 45-60 female), mid-age (45-55), young (25-34). Uncertainty in the model is related to the occurrence of health events. Finally, I assume that worker face health shocks with a conditional probability $p_t(A, G)$ that is jointly determined by age and gender. Introducing health risk allows me to control for the effect of health risk on labor market decisions (Rust and Phelan, 1997) and household finances (Gallagher et al., 2020).

4.1 Solution

The model is solved by backward induction. Starting from the period before retirement, I can solve for the optimal consumption (C_{T-1}) and if she works in formal markets (h^f_{T-1}), given the state variables, other assets (W_{T-1}) and pension assets (W^P_{T-1}), before retirement.[16] I calculate the maximum level of achievable utility before retirement, given the levels of savings at which you reach the second-last period, $V_{T-1}(W_{T-1}, W^P_{T-1})$. Iteratively, I can solve for the optimal solution

[16]See Appendix A.2 for details on the last period solution.

as follows:

$$\max_{C_t, h_t^f} \quad U(C_t) + \bar{\beta}\delta\tilde{V}_{t+1}(W_{t+1}, W_{t+1}^P) \tag{2}$$

$$W_{t+1}^P = \left(W_t^P + \kappa_t\left(h_t^f\right)\right)(1+r^*)$$
$$W_{t+1} = \left(W_t + y_t\left(h_t^f\right) - C_t - \varsigma_t\left(h_t^f\right)\right)(1+r) - \varepsilon_{t+1}\left(h_t^f\right)$$

$\tilde{V}_{t+1}(W_{t+1}, W_{t+1}^P)$ is the interpolated continuation value function, which is obtained from a grid calculated iteratively, see Appendix A.3.

It is worth noting that the solution for the dynamic saving problem with hyperbolic discounting does consider that the continuation-value function ($\tilde{V}$) differs from the current-value function (V), since this is the technical explanation of time inconsistent behavior.

4.2 Model Estimation

In this section I present the simulation method of moment estimation of the model for a low-educated worker that has an expected average life cycle income as in Figure 10a. The model abstracts from general equilibrium effects that can endogenously determine wages. The model incorporates health shocks that vary across the life-cycle. The conditional probability of experiencing a shock depends on gender and varies by age as in Figure 9. The out-of-pocket medical costs implied by a health shock also assume a different life-cycle pattern between men and women. Other relevant parameters used to solve the model are presented in Table 8.

The pre-reform labor market equilibrium is described by worker's optimal consumption policy and her decision to work in the formal market. The solutions of the model depend on two parameters that can encompass two behavioral mechanisms that are important in the behavioral economics literature. First, I study the role of time preference, where I compare exponential and hyperbolic discounting preferences. Second, I study how deterministic changes in the marginal utility of wealth at retirement can interact with impatience and present bias to predict the effect of the reform. In the model simulation, a higher δ parameter is associated to more patient workers, and under exponential preferences ($\bar{\beta} = 1$) this generates a constant marginal rate of substitution. In the case of hyperbolic discounting, the parameter δ controls dynamic consistency ($\delta \neq \bar{\beta}$). which makes workers behave as if they suffer from present bias. The difference between the marginal utility of consumption during worker's life and retirement is controlled by the wedge between parameters γ and υ. I fix

v at 0.5, which is equivalent to assume a square root utility function on pension consumption, and then I study variations of γ that controls the lifetime utility value of wealth at retirement. The implied crowding out elasticity of pension assets produced by the DiD regression is calculated by a simulation of expected contributions before the reform given an observed contribution pattern ($\hat{h}_t^f$). Then, I reduce the probability to contribute to account for the 10 perentage points reduction in the formal labor market participation after the reform ($\delta_t^h = -10\%$), according to the following deterministic process:

$$\hat{W_t^P} = \hat{W_{t-1}^P}(1 + r^*) + (\hat{h_t^f} + \delta_t^h)\hat{y_t^F}\tau \ \vee t = 1...T \tag{3}$$

where $\hat{W_t^P}$ measures the estimated pension assets at time t; r^* is the assumed return on pension assets; $\hat{h_t^f}$ is the estimated probability of contribution to the pension system at time t; $\hat{y_t^F}$ is the estimated formal earned income at time t; τ is the mandatory retirement savings rate; T is the lenght of the life-cycle; δ_t^h measures the estimated effect of the reform on the probability to contribute to the pension system.

I estimate a crowding out elasticity of pension assets of -0.15 from the 10 percentage point reduction in the probability to contribute obtained from the DiD estimator. This elasticity is calculated as the ratio between the counterfactual effect on pension assets at retirement with ($\hat{W}_T^{P*}$) and without the reform ($\hat{W}_T^P$), and the amount of subsidies provided by the government, using the following formula:

$$\hat{\varepsilon} = \frac{\hat{W}_T^{P*} - \hat{W}_T^P}{\left(p_l + \frac{p_l}{p_m}\frac{W_T^{P*}}{a(r_T^*)}\right)a_T - W_T^{P*}} \tag{4}$$

where $W_T^{P*}$and W_T^P are the pension assets accumulated at retirement with and without the pension reform; p_l is the minimum pension and p_m is the maximum pension threshold allowed to receive the pension top-up benefit; $a(r^*)$ is the cost of an annuity that pays one unit of pension per period while the retiree is alive, which is a function of the return on pension assets (r^*).

To understand under which conditions the life-cycle model can rationalize the estimated crowding out elasticity of -0.15. In Table 7 I document the estimates of worker's discount factor (δ) and worker's marginal propensity to consume before retirement (γ) that allow the model to produce a counterfactual behavior that matches the estimates obtained from the DiD regression. In Panel A of Table 7 a calibration of the elasticity is presented. The results suggest that in order to explain the behavior of workers under using the proposed model we need subjective discount rates above 17% (female with hyperbolic discounting) and a moderate change in the marginal utility of wealth at retirement. In Panel B, I show the estimated parameters using a simulated method of moments to match an average replacement rate before the reform of 30%, and a 10 percentage point reduction in the fraction of time contributing to the system. In this case, we can see that the model with hyperbolic discounting would predict a small increase in pension savings after the reform and the model with exponential discounting would produce a small reduction. In Panel C, the moments used to estimate the model are the elasticity and the workers' average replacement rate before the reform. In this case, the model with hyperbolic discounting predicts an elasticity that is closer to the empirically estimated. In Panel D, the moments used to estimate the model are the elasticity and the estimated effect on the fraction of time contributing to the system. In this case, the model with hyperbolic discounting can only explain the behavior of men. Although both types of time preference can potentially explain the crowding out elasticity, I argue that if treated workers increased their consumption after the reform, and did not substitute retirement and non-retirement assets, this behavior is inconsistent with the predictions under exponential discounting. It is the model with hyperbolic discounting preference that predicts, most of the time, that the penssion reform would reduce non-retirement assets after the reform, that could be seen as financially equivalent to the increase in debt accumulation, as is empirically estimated in Figure 9.

5 Identification Strategy

In this section, I examine the effects of the new pension subsidies introduced by the pension reform on workers' probability to save for retirement.

5.1 Instrument for pension subsidies

The reform established pension subsidies that are calculated with certainty only at retirement, based on the parameters established by the policy: the minimum pension (PBS) and the maximum eligible pension (PMAS) in Figure 1. The identification challenge is that pension subsidies that can be expected by workers in 2008 are unobserved. To circumvent this challenge, I propose to use workers' average income to poverty line ratio ($\overline{Y}_i$) and workers' fraction of months contributing to the pension system ($\overline{C}_i$) measured in 2007, as instruments of workers' expected pension assets in the absence of the reform. Following Engelhardt and Kumar (2011), I simulate the cross-section of pension benefits for a group of representative workers with life-cycle income profiles and its life-cycle probability to contribute to the pension system estimated using only labor market outcomes determined before the reform. I use a one-time national sample, namely, the 2006 Chilean Households Survey (CASEN). The estimated life-cycle income profiles and contribution probabilities are presented in Figure 10a. In Panel (a) and (b) of Figure 10a, the simulations show that high-education workers earn significantly more than low-education workers, evidence that is consistent with the findings of Fernández and Messina (2018). In Panel (c), we can see that estimated probabilities of high-education workers are more than 30 percentage point higher than low-income workers'. Then, the simulated pension assets at retirement can be calculated iteratively, as follows:

$$\hat{W_t^P} = \hat{W_{t-1}^P}\,(1 + r^*) + \hat{h_t^f}\hat{y_t^F}\tau \ \ \vee t = 1...T \tag{5}$$

where $\hat{W_t^P}$ measures the estimated pension assets at time t; r^* is the assumed return on pension assets; $\hat{h_t^f}$ is the estimated probability of contribution to the pension system at time t; $\hat{y_t^F}$ is the estimated formal earned income at time t; τ is the mandatory retirement savings rate; T is the length of working life.

The policy design determines pension subsidies through the minimum pension (PBS) and the maximum pension eligible for pension subsidies (PMAS). Then, the simulated pension subsidies at retirement can be calculated as the difference between the actuarial valuation of pension subsidies at retirement and the accumulated pension assets, as follows:

$$PS(W_T^P, r_T^*) = \begin{cases} \left(p_l + \frac{p_l}{p_m}\frac{\hat{W_t^P}}{a(r^*)}\right) a(r^*) - \hat{W_t^P} & 0 < \frac{\hat{W_t^P}}{a(r^*)} \leq p_m \\ 0 & \frac{W_T^P}{a(r^*)} > p_m \end{cases}$$

p_l is the minimum pension (PBS) established by design; p_m is the maximum pension threshold allowed to receive the pension top-up benefit (PMAS); $a(r^*)$ is the cost of an annuity that pays one unit of pension per period while the retiree is alive, which is a function of the return on pension assets' (r^*) and probabilities of life expectancy (q).[17]

[17]The cost of an annuity that pays \$1 until retirees's death can be calculated as follows:

In Table 1, I show how pension subsidies are determined by labor market outcomes observed before the reform: expected life-cycle income profile and probabilities of contribution to the pension system. Under the parametric assumptions presented in Table 8, I calculate that the present value of pension subsidies is 2% of the workers' discounted future incomes, for low-income and low-contribution workers. The simulations suggest that subsidies are expected to decay rapidly at higher incomes and probabilities of contribution. The simulations also predict that pension subsidies are concentrated on workers with an average income close to the minimum wage. However, both instruments monotonically reduce expected pension subsidies introduced by the reform. To the extent that workers' pre-reform labor market outcomes are a good predictor of workers' life-cycle outcomes, in the abscence the reform. An assumption that is justified by the theory of persistent individual labor market histories proposed by Wachter (2020). Under this case, the instruments are good proxies of the unobserved intention-to-treat of the reform in the cross-section of workers, and they can be used to assign workers into a treatment or control group.

Table 1: Estimated pension subsidies

This table show the estimated present value of pension subsidies, as a fraction of the discounted value of future incomes. The assumed income profiles and probabilities of contribution of workers are taken from Figure 10a. The parameters that determine expected contributions vary from low-education (-) to high-education (+). Incomes and probabilities in the middle range are obtained as five evenly distributed points calculated from the lower bound (low-education) to the the upper bouns (high-education) of incomes and probabilities, by age. The average life-cyle income and probabiliy of contribution for the representative workers are also presented.

		-	**Probability of contribution**			**+**
	$\overline{Y}/\overline{C}$	**34%**	**42%**	**50%**	**59%**	**66%**
-	**1.1**	2,0%	1,5%	1,0%	0,4%	0,0%
Life-cycle	**1.7**	0,5%	0,0%	0,0%	0,0%	0,0%
income	**2.4**	0,0%	0,0%	0,0%	0,0%	0,0%
profile	**3**	0,0%	0,0%	0,0%	0,0%	0,0%
+	**3.6**	0,0%	0,0%	0,0%	0,0%	0,0%

I test the relevance of both instruments using a linear regression model. I estimate the regression of standardized pension assets measured in the first semester of 2008, on workers' standardized average income to poverty line ratio ($\overline{Y}_i$), the fraction of months contributing to the pension system ($\overline{C}_i$), gender and linear and quadratic age effects, before the reform. In Figure 3, I confirm the positive and significant relationship between workers' earned income and their fraction of time contributing to the system (pre-2007) on workers' pension assets at the moment the pension reform

$a(r^*) = \sum_{n=1}^{\infty} \frac{(1-q_n)}{(1+r^*)^n}$, where q_n measures the probability that a retiree is deeath n years after retirement.

starts.

5.2 Difference-in-differences

In this section, I explain how the two instruments are used to identify the intensity of treatment on the cross-section of workers. First, I sort workers by their average earned income, or their fraction of time that have contributed to the system, before the reform. The two treatment groups are assigned by workers in the first tercile of workers' average income to poverty line ratio ($G_{Y,i} = 1$), or in the first tercile of time contributing to the system ($G_{C,i} = 1$). The workers in the highest terciles are assigned to the control groups ($G_{Y,i} = 3$ and $G_{C,i} = 3$). I study only the effect of the reform on the extensive margin because the saving rate to pensions is fixed by law. The average worker response is estimated using a dynamic difference-in-differences (DiD) estimation, where the focus is on the probability to contribute to the pension system. The following regression, identifies the effect of changes in the propensity to contribute to the pension system after the reform from changes in the estimated probability to contribute to the system between the treatment and control groups:

$$Cont_{i,t} = \beta_0 + \sum_{s=2006}^{2007} \beta_s Year(t_i = s)G_i + \sum_{s=2009}^{2012} \beta_s Year(t_i = s)G_i + \mathrm{A}G_i + \theta_i + \mathrm{Year}_t + \xi_{i,t} \tag{6}$$

where the outcome variable $Cont_{i,t}$ is a dummy variable that identifies if an individual i contributed to the pension system at month t; G_i is a generic dummy variable that identifies if worker i is part of the treated group or control group, given that assignment is based on historical income ($G_{Y,i}$) or worker's fraction of time contributing to the system ($G_{C,i}$); $Year(t_i = s)G_i$ is the product of a dummy variable that takes a 1 when a treated worker i at time t is observed in year s; AG_i are age-gender fixed effects that capture gender and life-cycle effects; θ_i are worker fixed effects that control for time-invariant characteristics of the worker i; $\xi_{i,t}$ is an error term. I cluster standard errors at individual level as the error term is likely to be correlated within individual trajectories.

In Equation 6, the focus of the attention is on parameters β_s that measures how the probability to contribute to the pension system changes for the workers most affected by the reform, relative to the group of workers that would unlikely benefit by the policy, taking 2008 as a baseline. The key identification assumption behind the proposed method is that there are no pre-trends on the probability to contribute to the pension system between the treated and control groups. Under this assumption, we can estimate using an ordinary least square (OLS) method that the reform discourages mandatory pension contributions when the coefficients β_s turn negative only after the reform starts. Alternatively, the new DiD estimator proposed by De Chaisemartin and d'Haultfoeuille (2022) to estimate intertemporal treatment effects that are robust of heterogenous treatment effects is used. One of the motivation is to deal with potential biases that can emerge from within changes in the treatment and control groups because of the sample restrictions described in Section 6. Sample restrictions are related to the typical starting working age (twenty-five years old) and the legal retirement age of 60 years old for females and 65 for males.

5.3 Continuous treatment

To ensure that workers estimated propensity to save after the reform depend on pension subsidies, and is not related to other factors that affect differently the treated ($G_{Y,i} = 1$ and $G_{C,i} = 1$) and control ($G_{Y,i} = 3$ or $G_{C,i} = 3$) workers after the reform. I propose to estimate a DiD with continous treatment focusing only on workers that are part of the treatment group. This empirical test is closer to my theory that predicts that the reform affect workers through its accumulated pension wealth before the reform. In a regression model, I estimate how workers' probability to contribute to the pension system vary at different levels of the instruments used to construct the simulated pension subsidies, after the reform. The effects are estimated form the following DiD estimator:

$$Cont_{i,t} = \beta_0 + \beta_1 \, Post_{i,t}\overline{Y}_i + \beta_2 \, Post_{i,t}\overline{C}_i + \beta_3 \, Post_{i,t}\overline{Y}_i^2 + \beta_4 \, Post_{i,t}\overline{C}_i^2 + \theta_i + \mathrm{Year}_t + \xi_{i,t} \tag{7}$$

where $\overline{Y}_i$ is the average income to poverty line ratio before the reform; $\overline{C}_i$ is the fraction of time contributing to the system before the reform; $Post_{i,t}$ is a dummy variable that takes a 1 if worker i is observed after June 2008, and 0 when the worker is observed in the pre-reform period (January 2007-June 2008); θ_i are individual fixed effects, or control variables available in the EPS 2006 survey, such as married and low-education status, and net worth; Year$_t$ are year fixed effects.

5.4 Heterogeneous effects

Motivated by the evidence on different types of retirement saving behavior documented by Chetty et al. (2014), in the analysis of a pension reform in Denmark. In this section, I study an alternative mechanism that might generate heterogenous responses among workers. I specifically focus on how incentives faced by the reform are affected by financial literacy, a non-financial factor that has been associated to retirement saving behavior (Lusardi and Mitchell, 2007). My test evaluates if treated workers with higher financial literacy respond more strongly to the incentives generated by the reform. Taking advantage of the availability of data for a subsample of workers that participated in the 2006 Social Protection Survey (EPS). I identify workers' financial literacy through a composite index constructed by a principal component analysis that combines three variables that measure financial knowledge. These three variables are dummies that identify if a worker is correct in responding the three questions advocated by Lusardi and Mitchell (2011). The first question intends to measure knowledge regarding compound interest (CompInt), the second is a question that involves interest and inflation (RealRet), and the third measures the understanding of diversification (Diversification). As documented in Table 2, the first principal component explains 49% of the variation in these variables and has positive loadings in the three quesions. I label the index constructed using the first principal component as $FinLit$.

Table 2: Principal components analysis of financial literacy

This table describes the principal components of variables that proxy financial literacy: *CompInt, RealRet*, and *Diversification*. In Panel A, the eigenvalues for different components and a variance decomposition are reported. In Panel B, the factor loadings used to construct our index of financial literacy are reported.

Panel A. Eigen values of the correlation matrix				
	Eigenvalue	Difference	Proportion	Cum.
Comp1	1.46	0.67	0.49	0.49
Comp2	0.79	0.04	0.26	0.75
Comp3	0.75		0.25	1.00

Panel B. Corresponding eigen vectors			
	Comp1	Comp2	Comp3
CompInt	0.59	-0.21	-0.78
RealRet	0.58	-0.56	0.59
Diversification	0.56	0.80	0.21

To disentangle the heterogeneous effects of the policy on workers' propensity to contribute to the pension system, I focus on analyzing the financial incentives and financial literacy margins, simultaneously. Therefore, I propose to use the method developed by Cattaneo and Jansson (2018) to estimate a nonparametric kernel regression to study the cross-section of changes in workers' probabilities to contribute to the pension system, within the low-income ($G_{Y,i}$) or low-contribution ($G_{C,i}$) groups, before and after the reform. Mathematically, the empirical model can be written as follows:

$$P_{i,post} - P_{i,pre} = \beta_0 + \beta_{FinLit} FinLit_i + \beta_D D_i + \xi_{i,t} \tag{8}$$

where $P_{i,post}$ is the fraction of months that worker's i contributes to the pension system after June 2008; $P_{i,pre}$ is the fraction of months that worker's i contributes to the pension system during the pre-reform period (January 2007-June 2008); $\beta_{FinLit} FinLit_i$ and $\beta_D D_i$ measure semiparametrically the marginal effect of financial literacy and worker's financial incentives associated to worker's i pre-2007 labor market outcomes ($\overline{Y}_i$ and $\overline{C}_i$).

6 Data and summary statistics

I use data from different sources. First, I work with the publicly longitudinal administrative dataset obtained from the Chilean Superintendency of Pensions, a government authority that oversees the activities and compliance of the private institutions managing pension funds. The dataset includes administrative records on 28,135 randomly selected individuals that participate in the pension system. The dataset runs monthly between November 1981 and December 2017 and contains information on individual demographic characteristics (e.g., gender and age), participation in the formal labor market, taxable earned income in formal jobs, the amount of accumulated retirement savings, and the date of retirement. For the primary analysis, I limit the sample to individuals who earned at least some taxable income in the formal labor market between November 1981 and December 2017, were present in the data both prior to and after the 2008 pension reform, were aged 25 and over, and were under the retirement age (under 60 for females and under 65 males) at any point during the period of study. Each individual was observed since the date of their affiliation with the pension system. After these restrictions, the final analytical sample includes 16,810 individuals, corresponding to 4,694,855 monthly observations. Second, to study alternative mechanisms that can explain the estimated effects obtained using administrative records. I use information of marital status, number of kids, education, net worth, and financial literacy from the 2006 Social Protection Survey (EPS). This public dataset includes information from 9,408 heads of household, which can be linked to their historical pension contributions records. Finally, descriptive evidence is also presented from a pooled cross-section of the available rounds of the Chilean Households Survey (CASEN) during the period 1996-2013.

In Table 3, means for the key variables that are available in the the administrative panel dataset are documented. The sample is divided in three groups based on pre-2007 workers' average historical salary ($\overline{Y}_i$), and an alternative split based on workers' fraction of months saving for retirement ($\overline{C}_i$) since worker i joined the pension system. In Panel A, the means of the following variables are compared between the low and high-income group: fraction of men (Men), the average age (Age), the fraction of months with pension contributions ($\overline{C}_i$), average monthly income as a fraction of the poverty line ($\overline{Y}_i$), and pension assets as a fraction of the annual minimum wage. In Panel B, the same descriptive statistics are presented for workers sorted by their fraction of time contributing to the system. These statistics confirm that simulated pension subsidies in Table 1 would be concentrated only on workers with an average life-cycle income and fraction of months with contributions at retirement that coincide with the empirical average income to poverty line ratio and fraction of time contributing to the system of workers in the bottom group in terms of income (Low Inc) and months of contributions (Low Cont) that are summarized in Table 3.

Table 3: Summary statistics of the panel dataset

This table documents a mean test for groups sorted by worker's average income to poverty line ratio as a percentage of the poverty line ($\overline{Y}$), or the fraction of months that has contributed ($\overline{C}$), before 2007. To test for balance, we follow Imbens and Wooldridge (2009) that computes the differences in means between two groups divided by the standard deviation in the full sample, such that a difference above 0.25 is considered unbalanced. In Panel A, the groups are formed based on income. In Panel B, the groups are formed based on frequency of contributions.

Panel A	Low Inc	Mid Inc	High Inc	diff/sd	
N° of workers	2,249	5,390	7,234	Low-High	Mid-High
Men	46%	61%	66%	-0.40	-0.12
Age	35.3	35.7	37.9	-0.24	-0.20
Contribution	35.1%	61.7%	80%	-0.90	-0.36
IPL	1.1	2.0	5.2	-1.39	-1.09
$\overline{Y}$	1.0	1.9	5.1	-1.79	-1.37
C	35.1%	61.7%	80%	-1.29	-0.52
Pension assets	1.0	1.9	6.3	-0.88	-0.73

Panel B	Low Cont	Mid Cont	High Cont	diff/sd	
N° of workers	5,578	4,698	6,534	Low-High	Mid-High
Men	43%	63%	64%	-0.42	-0.02
Age	37.1	34.5	38.7	-0.15	-0.39
Contribution	14%	60%	94%	-1.61	-0.68
IPL	1.6	2.5	4.0	-0.80	-0.50
Y	1.4	2.4	4.0	-1.11	-0.66
C	14%	60%	94%	-2.32	-0.98
Pension assets	1.3	2.4	6.5	-0.88	-0.68

In Table 4, a similar mean test by group of workers is documented for the socioeconomic variables that can be found in the EPS 2006. As we can see, in this subsample we find differences in terms of age and gender composition of the groups. Other difference between groups is related to the lower levels of financial literacy and formal educational attainement among the groups with historically low contributions and incomes. To the extent that financial literacy mediates the response of workers to the pension reform. The heterogenous effects of the reform along the financial literacy margin are studied using this alternative sample.

Table 4: Summary statistics of the panel dataset

This table documents summary statistics for socieconomic variables that are present in the EPS 2006. To test for balance, we follow Imbens and Wooldridge (2009) that computes the differences in means between two groups divided by the standard deviation in the full sample, such that a difference above 0.25 is considered unbalanced. In Panel A, the groups are formed based on income. In Panel B, the groups are formed based on frequency of contributions.

Panel A	Low Inc	Mid Inc	High Inc	diff/sd	
N° of workers	7074	5407	4174	Low-High	Mid-High
Men	44%	55%	63%	-0.37	-0.16
Married	44%	46%	52%	-0.16	-0.13
Kids	1.0	1.1	1.1	-0.06	-0.05
Age	39.8	37.8	38.6	0.12	-0.09
FLI	0.1	0.2	0.6	-0.45	-0.37
Low Educ	95%	91%	62%	0.87	0.77
$NetWorth	31.0	20.8	-2.5	0.2	0.1
Panel B	**Low Cont**	**Mid Cont**	**High Cont**	**diff/sd**	
N° of workers	6813	6051	9898	Low-High	Mid-High
Men	41%	58%	58%	-0.35	0.00
Married	0.5	0.5	0.5	-0.04	-0.04
Kids	108%	107%	106%	0.02	0.01
Age	38.3	38.7	40.1	-0.19	-0.14
FLI	0.1	0.4	0.4	-0.28	-0.06
Low Educ	91%	78%	78%	0.35	0.00
$NetWorth	-0.8	4.5	34.4	-0.2	-0.1

Finally, I provide a descriptive evidence of the self-reported participation in the formal labor market of workers with low incomes around the time of the analyzed pension reform using CASEN's pooled cross-sectional datasets. In Figure 2, I document the fraction of workers that reports that is contributing to the pension system conditional on earning up to the minimum wage (1MW) and the same fraction for workers that earn a salary that is between one and two times the minimum wage (2MW). As we can see, self-reported contribution to pensions fall after the 2008 financial crisis for both types of workers, which is consistent with the transitory increase in the general level of unemployment. After the reform, in 2013, self-reported participation in the pension system of workers that earn up to the minimum wage never recovered. This trend is in contrast to the dynamic of the participation of workers earning between 1 and 2 times the minimum wage also documented in Figure 2. These figures offer preliminary evidence that workers earning the minimum wage reduced their propensity to save for retirement.

Figure 2: Self-reported contribution to pensions

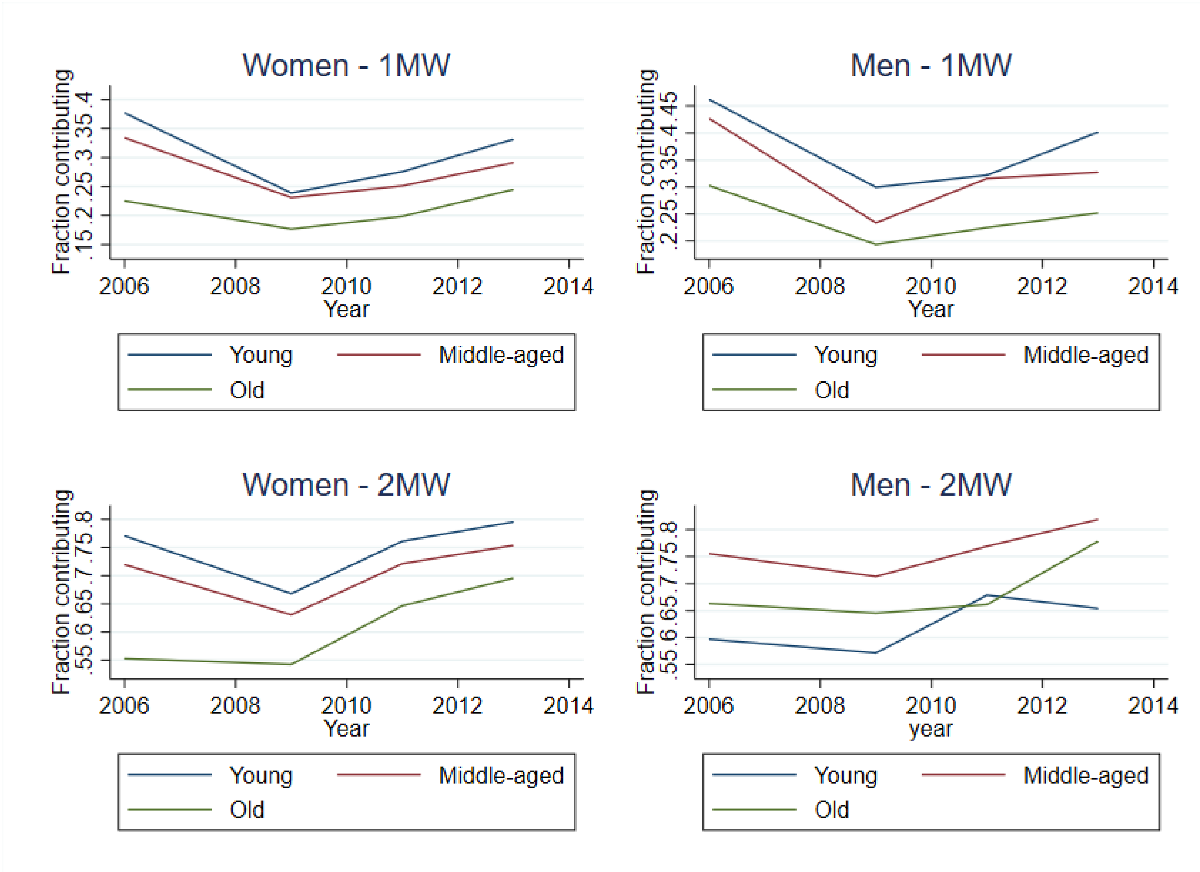


Figure plots the fraction of female and male workers that self-report being a contributor to the pension system from CASEN's surveys (2006, 2009, 2011, and 2013). In this figure, we can measure the fraction of workers that make at least the minimum wage (1MW), and workers that self-report earnings between one and two times the minimum wage (2MW).

7 Empirical Results

This section presents the results of the difference-in-differences regression. I begin presenting the results for the comparison between identified treated versus control groups based on workers' pre-2007 average salary ($\overline{Y}_i$) or its fraction of months contributing to the system ($\overline{C}_i$). Figure 4 presents the time-varying estimated coefficient of interest (β_s) from Equation 6. In Panel A of Figure 4, the estimated time-varying effect of the reform using the both instruments to identify the treated and control group is documented. In this analysis, we find a reduction in the probability to contribute to the pension system of 10 percentage points after 4 years of the reform, and this effect appears to be permanent. In Panel B of Figure 4, I estimate the instantaneous treatment effects proposed De Chaisemartin and d'Haultfoeuille (2022) and I find a higher 15 percentage point reduction in the probability that a treated worker save for retirement after 4 years of the reform.These results suggest that the reform affected negatively the propensity to contribute of workers that can benefit from the pension subsidies.

7.1 Heterogeneity according to financial incentives

In this subsection, I focus in providing additional evidence on the reduced form estimated reductions in workers' probability to contribute to the pension system, after the introduction of the minimum pension program. Table 5 shows the estimated coefficients (β_s) of Equation 7, that measure changes in the probability to contribute to the pension system within workers that are part of the identified treated groups (low-income,$G_{Y,i}$, and low-contribution, $G_{C,i}$). In the left panel I show the results for the administrative dataset, the estimated coefficients imply a 10 percentage point reduction to a 2 percentage point increase in the probability to contribute to the pension system for a worker that earns the minimum wage and contribute 30 percent of the time to the pension system before the reform. In the right panel I show the results using workers that can be linked to the EPS survey dataset. In this case, I estimate an average increase in the probability to contribute to the pension system of 43 percentage point. These contradictory results suggest that workers that participate in the 2006 EPS survey are a selected sample that respond differently to other workers, or it can be evidence of heterogeneous treatment effects bias that is discussed in the following section.

7.2 Heterogeneity according to financial literacy

In this subsection, I document the analysis that addresses heterogenous treatment effects bias. Specifically, I show how financial literacy can shape the response of workers to the pension reform that introduced subsidies that are a function of pension assets at retirement. In Figure 5, the results of the predicted probabilities to contribute obtained from the semiparametric regression described in Equation 8 are documented. As we can see, Figure 5 suggest that the two proxies of expected pension subsidies, at the moment the pension reform was public information, are negatively related to changes in workers' probabilities to contribute to the pension system after the reform, a result that is consistent with the evidence from my main DiD estimators. The plots also suggest that for an average worker that earned the minimum wage, on average, or that contributed only 30% of the time to the pension system. The estimated probabilities of contribution to the pension system drop 25 percentage point, approximately, after the reform. This result would be consistent with an underestimation of the average treatment effect presented in our DiD analysis. On the other hand, Figure 5 suggest that financial incentives tend to disappear at higher levels of workers' average income to poverty line ratio (Panel A) or fraction of time contributing to the system before the reform (Panel B). This result is consistent with pension subsidies that affect only workers that have low retirement savings as I will theoretically analyze in the next section. In Figure 5, I also show that financial incentives are not the only factor that matters in understanding how workers' propensity to save for retirement change after the reform. As we can see, among workers treated by the reform, the less financial literate would cut down their propensity to save for retirement less than the more financially educated worker. This result is consistent with Lusardi and Mitchell (2007) interpretation of financial literacy. At low levels of financial literacy workers would be less able to plan for an adjustment of the formal labor supply to take advantage of pension subsidies.

7.3 Robustness

In this section, I describe the results of multiple robustness tests. First, I calculate how the baseline DiD estimator changes by age groups and gender, two demographic factors that in theory determine the response to the policy. Second, I conduct a placebo test to analyze the effects of the reform on workers that can expect to benefit less by pension subsidies, based on the results of the simulations presented in Table 1. The placebo test uses workers in the middle range of our proposed instruments as the treated group, maintaining the same control groups as in the baseline analysis. Third, I study the effects of the reform on self-reported net worth, excluding pension assets, on the subsample of workers that can be observed on the administrative and survey dataset. This test can shed some light, indirectly, on how unobserved workers' propensity to consume is affected by the reform. Finally, I estimate the effect of the reform from time-varying estimates of the probability to contribute to the pension system of workers self-reporting a labor income around the minimum wage, using the 2006, 2009 and 2011 Chilean Households Survey (CASEN). The results are obtained from a conditional mixed process estimator that simultaneously fits the cross-section of labor market choices: self-reported contributions, labor income, and hours of work. In this analysis, I also find a 10 percentage points reduction in the probability that a worker that earns the minimum wage contributes to the pension system, after the reform.

In Panel (a) of Figure 6, I show the estimated DiD coefficient β_s from Equation 6 by age groups. The coefficient does not change significantly when I restrict the analysis to age groups, for treated workers classified based on the time they have contributed to the pension system. In this case, I cannot reject that the reduction of a 10 percentage point in the probability to contribute to the pension system is homogenous across age groups. On the contrary, when I analyze the effects on the treated group formed by workers in the bottom tercile of workers' average income to poverty line ratio. Panel B of Figure 6 suggests that the reform could have reduced the propensity to contribute of young workers more than middle-aged and old workers. In Figure 7, I analyze gender differences on the estimated average treatment effect. Based on this analysis, I cannot reject that workers from both genders reduced their propensity to contribute to pensions in a similar manner.

Second, in the placebo test presented in Figure 8, I estimate the same DiD regression but using the middle-income and middle-contribution workers as the treated groups, using the same control groups. The treatment effect on middle-contribution workers is presented in Figure 8. These result suggest that the estimated trend follows the general evolution of unemployment, where the effects on the probability to contribute are transitory. I only find a negative effect when I measure the effects on workers that are in the middle range of workers' average income to poverty line ratio. In this analysis, I find only a two percentage point reduction in their propensity to participate in the pension system after the reform. However, it could not be ruled out that the estimated effect is driven by a negative pre-trend before the reform starts.

Third, I use a quantile regression to understand the effect of the pension reform on workers' net worth. At any chosen quantile, I ask how a marginal increase in the instruments of simulated pension subsidies affect net worth after the reform, controlling by workers' financial literacy and the level of the instrument. Net worth is selected because it includes debt that can be a proxy for an increase (decrease) in unobserved workers' propensity to consume. Coefficient estimates at the 25th through 75th quantiles of net worth are presented in Figure 9. The estimated coefficients by the conditional quantiles of net worth suggest a negative marginal effect of the reform on net worth – consistent with the crowding out of non-pension assets. However, this analysis does not consistently replicate the result of Engelhardt and Kumar (2011), where crowding out was concentrated at higher levels of non-pension wealth. Figure 9 shows that only when the intensity of treatment of the pension reform is measured by workers' average income to poverty line ratio is when Engelhardt and Kumar

(2011) empirical finding is replicated.

Finally, in Table 6 I present the results of a conditional mixed process estimated using annual cross-sectional survey data. Applying this empirical model allows me to estimate a relationship between self-reported contributions (probit model), hours of work (linear model) and income (linear model) simultaneously, while controlling by socioeconomic factors. In the case of self-reported contributions, the estimated coefficients associated to income in the probit regression suggest that workers that earn up to the minimum wage reduced their contribution by approximately 4% between 2006 and 2011. The opposite effect is documented for the case of wokers that earn between 1 and 2 times the minimum wage. This result is consistent with the idea that the reform did not reduce the incentives to save for retirement of workers that expect to benefit less by pension subsidies in the future.

8 Discussion

The minimum pension reform had the objective to increase retirement income of pensioners that had not accumulated enough assets during their working life. These social benefits intend to redistribute income towards pensioners that experienced events which society considers fair to compensate, for example, workers that faced multiple periods of unemployment during their working life, or people that are absent from the formal labor market because of sickness or childcare responsibilities. However, as has been theoretically shown, this type of policies can produce “freeloaders”, which are workers that take advantage of the transfer system (Saez and Stantcheva, 2016). Therefore, when governments seek to implement a budget neutral minimum pension reform they need to anticipate how potential “freeloaders” can cause a systemic crowding out of pension assets, which would finally raise the fiscal cost of the social program.

My estimations suggest that the reform reduced the probability to contribute to the pension system at least in 10 percentage point, for a worker with incomes around the minimum wage. The implied elasticity of crowding out of pension subsidies on accumulated pension assets at retirement is estimated at -0.15. In other words, an average worker that is eligible to claim $1 of pension subsidies at retirement, would reduce the amount of accumulated pension assets by $0.15. This estimate is in the lower range of what has been documented in the Section 3. However, in the empirical analysis I also show higher estimated effects on the probability to contribute to the pension system of treated workers with higher levels of financial literacy. For example, if I estimate a 20 percentage point effect on the probability to contribute, I find a crowding out elasticity of -0.27. In the case of stronger a reduction of 30 percentage point in the probability to contribute to the system, the estimated elasticity is -0.37. The implications of these estimates are related to the projections of the expected fiscal costs of a pension reform for a representative low-income worker. To ilustrate this point, I estimate the government expenditure on pension subsidies at worker's retirement, with respect to the simulated subsidies of workers under the model that fits a less active response to the incentives generated by the reform. My results suggest that governments would face a fiscal cost that is 12% higher than expected subsidies, using pre-reform labor market behavior, which is generated by a crowding out elasticity of -0.15. The fiscal costs of the same reform to a more financially literature population can imply elasticities that are around -0.27 to -0.37, implying an extra cost in pension subsidies for the government of 24 to 35%.

9 Conclusion

In order to design an effective and equitable pension system, understanding retirement saving behavior of the population is critical. In the Chilean case, as the first country to privatize its social security system, offers important insights into human behavior for policymakers and economists. After more than 30 years since the defined contribution system was implemented, a relatively high fraction of the population retired with relatively low levels of pension assets, which has translated into low pensions (and low replacement rates). In 2008 a pension reform started providing a minimum pension to workers that could not self-finance this minimum level. In addition, a top-up benefit based on accumulated pension wealth at retirement was introduced for pensioners that can self-finance a pension below some known threshold. The structural econometric literature warned that this reform could reduce the incentives to save for retirement, given that this program introduced an implicit tax on pension savings (Joubert, 2015). This research documents that the reform reduced the propensity to save for retirement of workers that were expected to accumulate fewer pension assets at retirement. My results suggest that lower retirement savings occur through higher informality to evade mandatory pension contributions. Second, this paper finds evidence that suggests that at low levels of pension assets, an additional dollar of savings would be associated to a marginally higher probability of opting out of the pension system. A result that is consistent with the idea that the reform created an implicit tax on pension assets among low–income workers. Third, this paper documents evidence of heterogenous effects along the financial literacy margin. These empirical results suggest that financial incentives to evade mandatory pension contributions are mediated by workers' financial literacy. Consistent to Lusardi and Mitchell (2007), I find that at low levels of financial literacy workers respond to the reform in a way that is less associated to financial incentives. The main implications of my results are related to the design of minimum pension programs that intend to redistribute income through the pension system. For example, a central planner that intends to conduct a minimum pension reform as a budget-neutral reform, would have to increase taxes more than what is needed, or could decide to offer a less generous pension benefit if the population is more financially literate.

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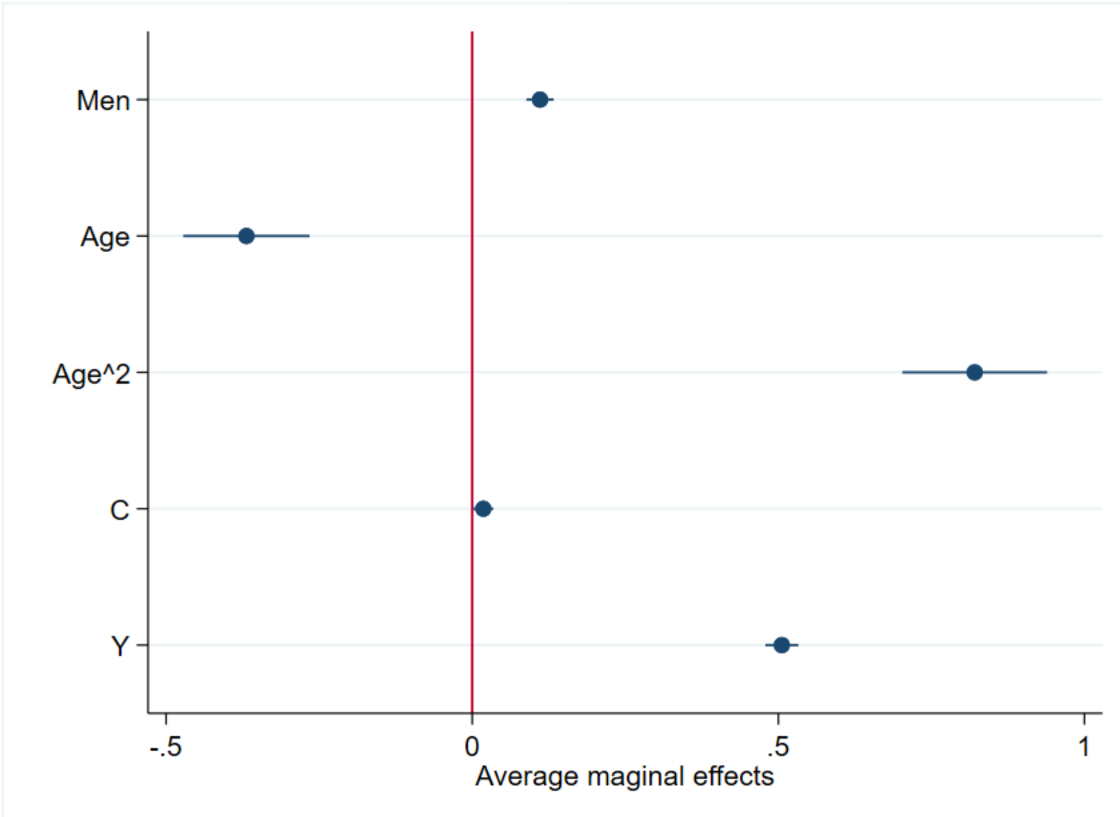
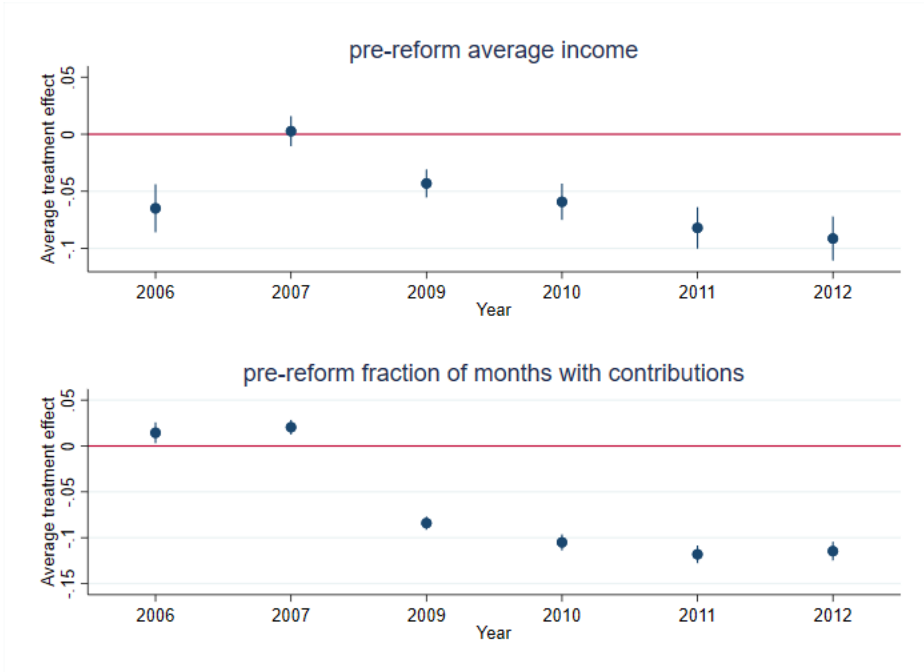


Figure 3: Marginal effects on standarized pension assets

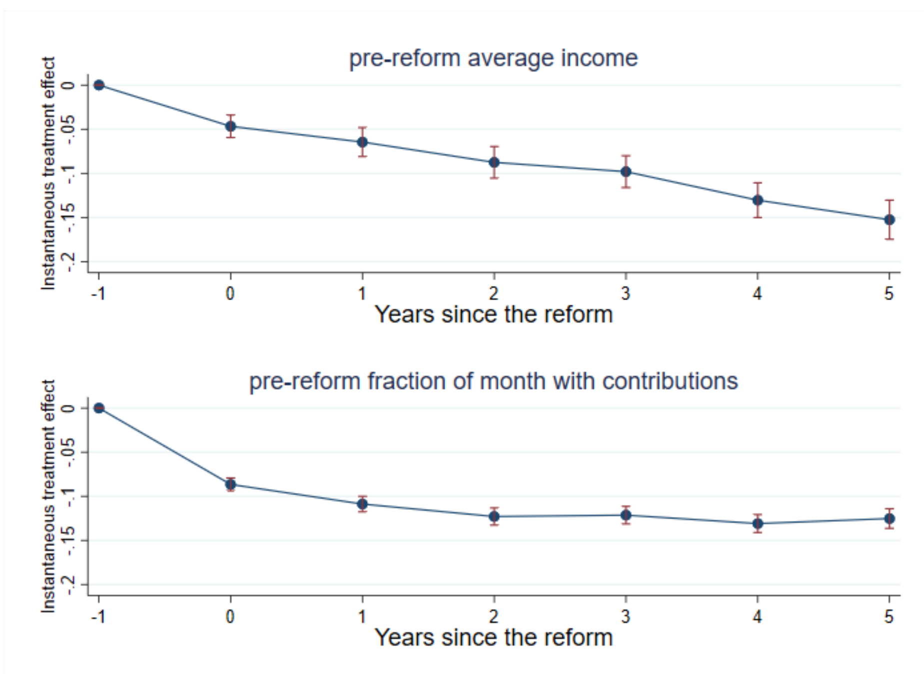
The figure shows the average marginal effects associated to explanatory variables using a linear regression model:

$$W_{i,t}^{P} = \alpha + \beta_1 \overline{Y}_i + \beta_2 \overline{C}_i + \beta_3 Age_{i,t} + \beta_4 Age_{i,t}^2 + \beta_5 Men_i + \epsilon_{i,t}$$

where all variables have been standarized. The outcome variable $W_{i,t}^{P}$ measures pension assets. Important explanatory variables include linear and quatric terms on age ($Age_{i,t}$ and $Age_{i,t}^2$), workers' average income to poverty line ratio ($\overline{Y}_i$) and frequency of contributions ($\overline{C}_i$) of worker i. The R^2 of the regression is 50%. Standard errors are clustered at worker level, resulting on a sample 14,531 workers.



(a) OLS estimates



(b) De Chaisemartin and d'Haultfoeuille (2022) DiD estimator

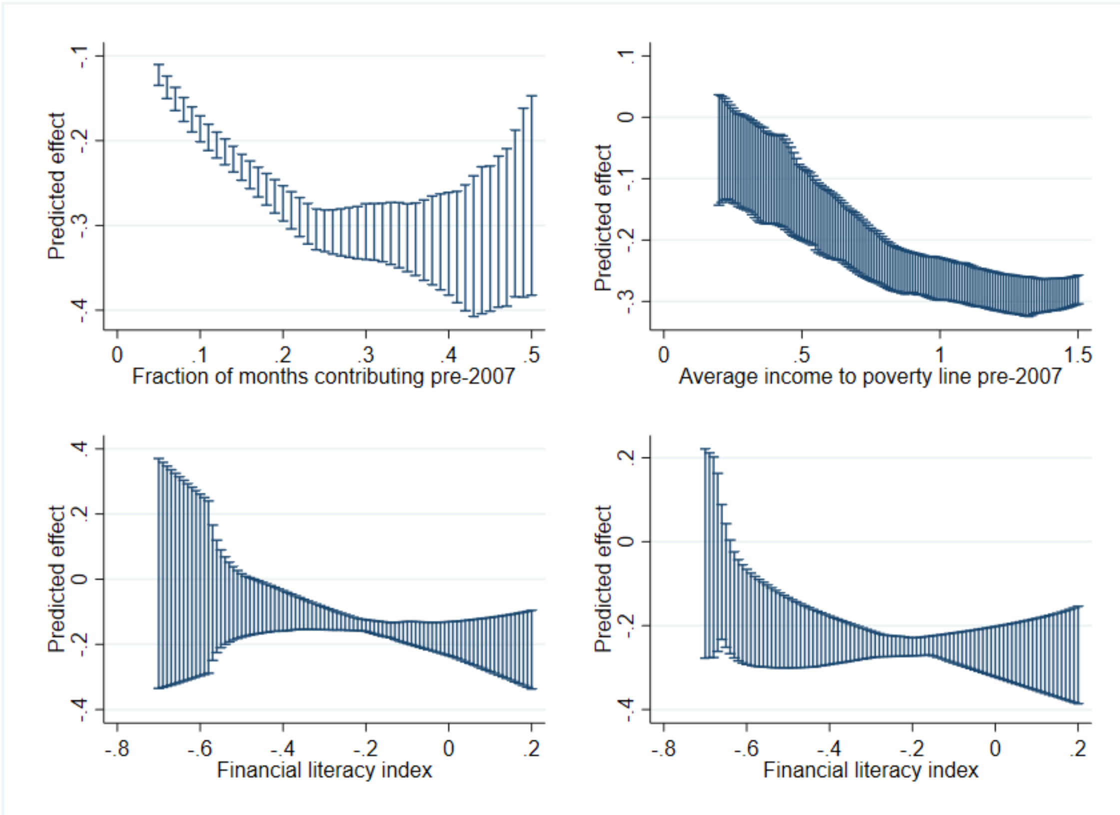
Figure 4: Dynamic difference-in-differences

In Panel (a), the figure shows the coefficient β_s of Equation 6 where the outcome variable is a dummy that identifies if an individual i is contributing at time t ($Cont_{i,t}$). The coefficients are measured using the low-income and low-contribution groups as treatment groups, and the high-income and high-contribution groups as control groups. In Panel (b) the instantaneous treatment effects using by assignment to treatment and control groups based on income and fraction of months with contributions.

Table 5: Difference-in-differences with continuous treatment

This figure shows the coefficient β_c of Equation 7, where the outcome variable is a dummy that identifies if an individual i is contributing at time t ($Cont_{i,t}$). In this case the coefficient β_c measures the marginal effect on the probability to contribute to the pension system at different levels of the instruments of pension subsidies, after the reform. The average treatment effect at different levels of the average income to poverty line ratio ($\bar{Y}_i$) is presented on the left-hand side of this figure. On the right side of this figure, the effect using the fraction of time with contributions ($\bar{C}_i$) is presented.

	Panel (a): Administrative dataset						*Panel (b): Administrative and survey dataset*					
Dependent:	*Contribution*											
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
$Post_{i,t}\overline{Y}_i$	-0.070***		-0.013***	-0.024		-0.031***	0.431***		-0.003	0.725*		-0.075***
	(0.019)		(0.004)	(0.037)		(0.007)	(0.083)		(0.009)	(0.386)		(0.027)
$Post_{i,t}\overline{C}_i$		-0.324***	0.111***		-1.527***	-0.138**				-0.134		0.007***
		(0.037)	(0.017)		(0.127)	(0.062)				(0.188)		(0.003)
$Post_{i,t}\overline{Y}_i^2$				-0.024		0.003***		1.300***	1.359***		1.277***	1.738***
				(0.030)		(0.001)		(0.064)	(0.046)		(0.241)	(0.170)
$Post_{i,t}\overline{C}_i^2$					4.141***	0.338***					0.044	-0.465**
					(0.460)	(0.065)					(0.483)	(0.204)
N	267042	660136	529789	267042	660136	529789	2623	5955	5377	2623	5955	5377
Adj. R-squared	0.387	0.143	0.261	0.388	0.145	0.262	0.217	0.383	0.393	0.218	0.383	0.399
Contros	Worker, age-gender, year fixed effects						Married status, low education, net worth in 2006, and year fixed effects					



The figures show the coefficient β_s of Equation 6 where the outcome variable is a dummy that identifies if an individual i is contributing at time t ($Cont_{i,t}$). In both cases the coefficient β_s measures the relative probability that an individual in the low-income group (Panel A) or middle income group (Panel B), based on pre-2007 data, is contributing to the pension system before and after the reform is implemented (red line).

Figure 5: Estimated effects from semiparametric regressions

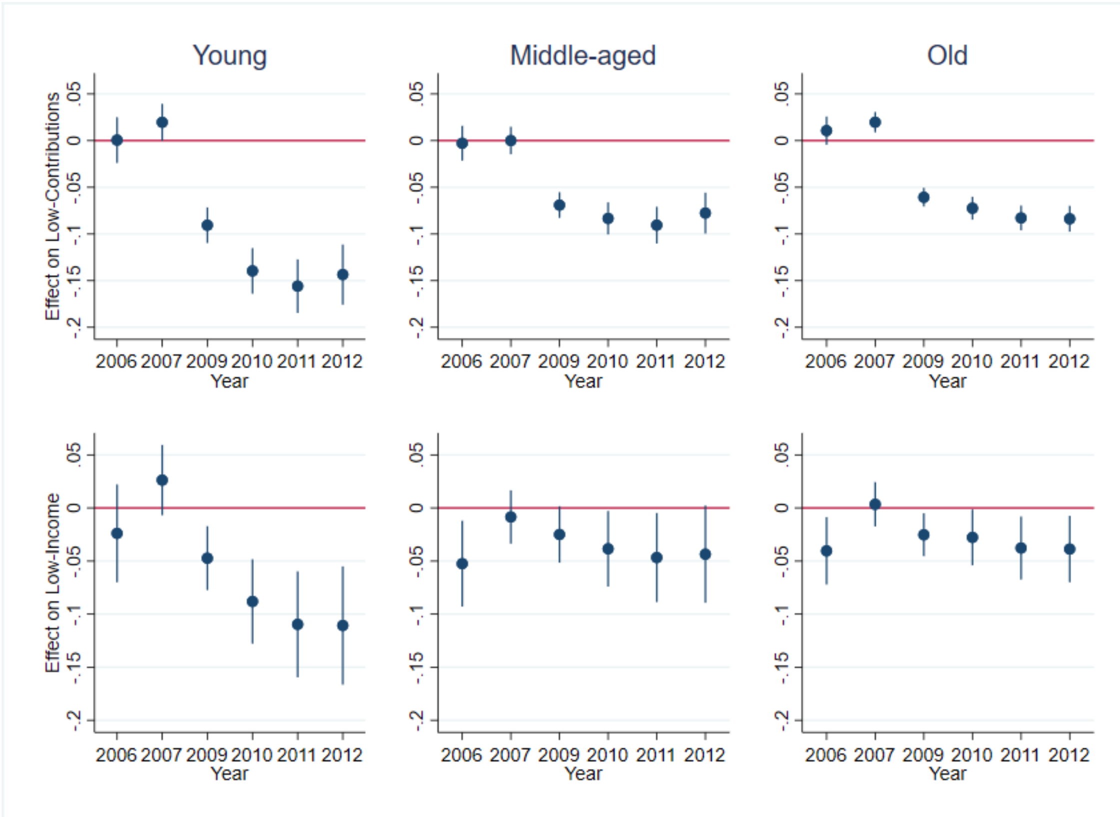


Figure 6: Dynamic difference-in-differencess, by age-group

The figures show the coefficient β_s of Equation 6 where the outcome variable is a dummy that identifies if an individual i is contributing at time t ($Cont_{i,t}$). In both cases the coefficient β_s measures the relative probability that an individual in the low-income group (Panel A) or middle income group (Panel B), based on pre-2007 data, is contributing to the pension system before and after the reform is implemented (red line).

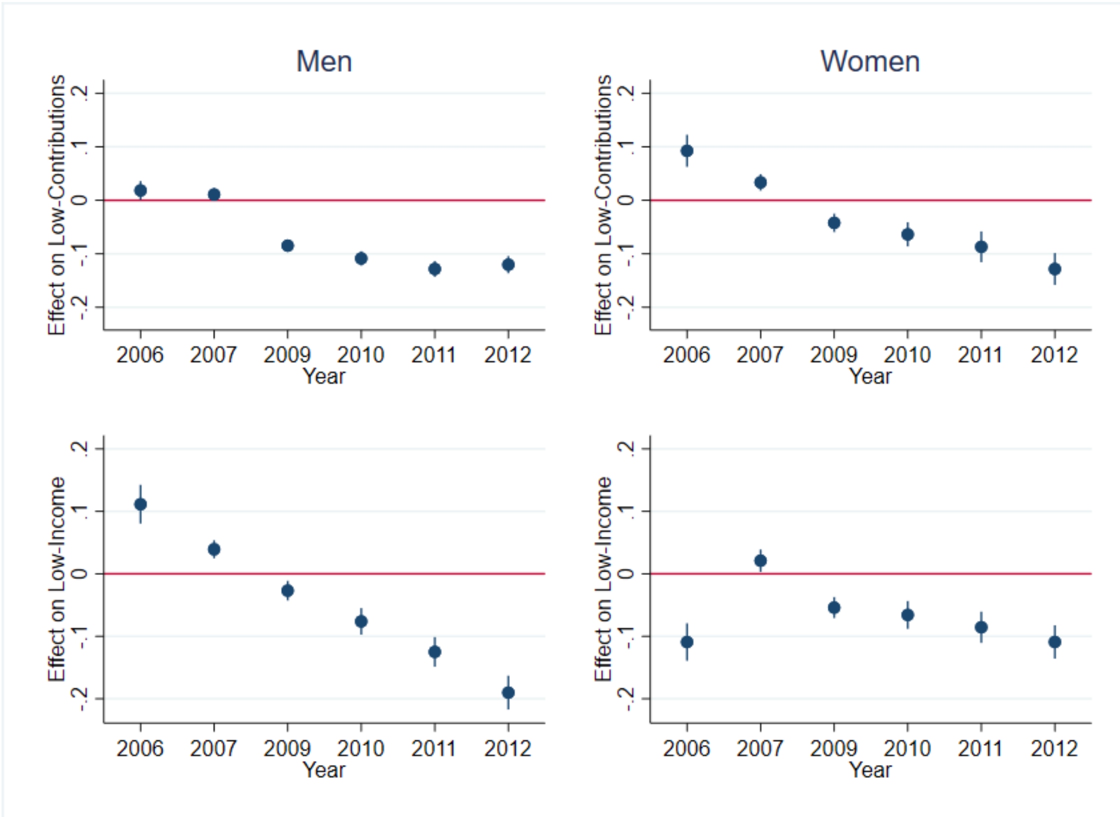


Figure 7: Dynamic difference-in-differences, by gender

The figures show the coefficient β_s of Equation 6 where the outcome variable is a dummy that identifies if an individual i is contributing at time t ($Y_{i,t}$). In the first row, the relative differences in the coefficients are calculated for men in the low-contribution (left) or low-income groups (right). In the second row, the relative differences in the coefficients are calculated for women in the low-contribution (left) or low-income groups (right).

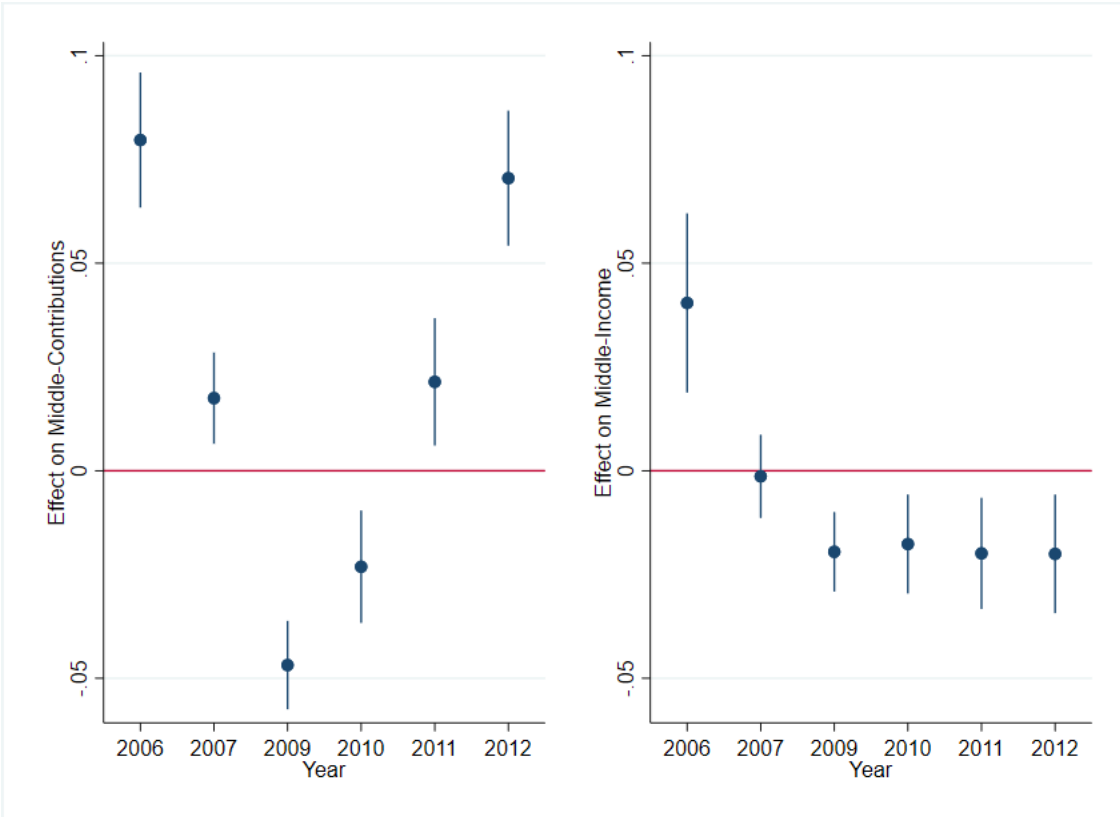


Figure 8: Dynamic difference-in-differencess: placebo test

The figures show the coefficient β_s of Equation 6 where the outcome variable is a dummy that identifies if an individual i is contributing at time t ($Y_{i,t}$). In both cases the coefficient β_s measures the relative probability that an individual in the placebo group based on income (Panel A) or the placebo group based on the fraction of time with contributions (Panel B), based on pre-2007 data, is contributing to the pension system before and after the reform is implemented (red line).

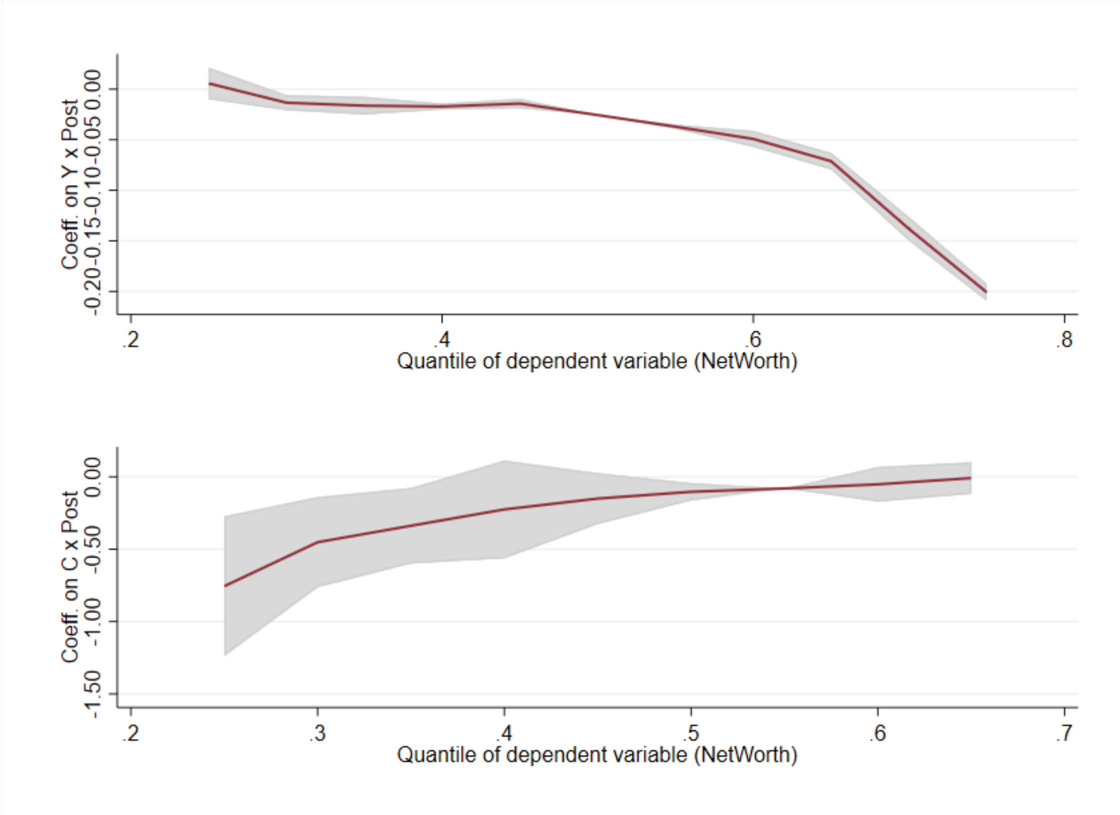


Figure 9: Quantile regression estimates of the effect of the pension reform in self-reported net worth
Figure plots the predicted marginal effect of the instruments: average income to poverty line ratio (above) and the fraction of time with pension contributions (below) on workers net worth at different quantiles of net worth. Net worth is calculated as a fraction of the annual minimum wage, making the magnitude of coefficients directly interpretable. The figure shows the coefficient estimates at every 5th quantile, from the 25th to the 75th. The shaded 95% CI is recovered through bootstrap (100 repetitions). The regression specification is given by:

$$W_{i,t}^{P} = \alpha_0 + \alpha_1\, Post_{i,t} D_i + D_i + FinLit_i + \text{Year}_t + \epsilon_{i,t}$$

where D_i refers to the instruments of pensions subsidies (average income to poverty line ratio, $\overline{Y}_i$, or fraction of time contributing$\overline{C}_i$); $Post_{i,t}$ is a dummy variable that takes a 1 if worker i is observed after June 2008, and 0 when the worker is observed in the pre-reform period the outcome variable; $FinLit_i$ measures financial literacy of worker i before the reform. The sample used to estimate this regression are the 2006, 2009, 2012 and 2015 rounds of the EPS survey.

Table 6: Simultaneous equations model: Conditional mixed process

	Contribution			Hours of work			Income		
MW<1	2006	2009	2011	2006	2009	2011	2006	2009	2011
Income	1.931***	1.366***	1.487***	18.488***	16.901***	19.506***			
	(47.92)	(25.54)	(31.54)	(701.01)	(481.39)	(617.67)			
Hours of work	0.010***	0.008***	0.012***						
	(13.33)	(8.25)	(14.82)						
Mid-age	-0.065**	-0.080*	-0.130***	-0.055**	0.171***	0.482***	-0.012	-0.015	0.003
	(-2.82)	(-2.43)	(-4.30)	(-3.16)	(6.99)	(21.03)	(-0.77)	(-0.72)	(0.17)
Old	-0.236***	-0.147***	-0.217***	-0.070***	-0.508***	0.434***	-0.048***	-0.03	-0.017
	(-10.91)	(-5.00)	(-8.08)	(-4.28)	(-23.36)	-21.5	(-3.40)	(-1.66)	(-1.05)
Low education	-0.290***	-0.565***	-0.458***	2.434***	2.719***	1.779***	-0.039	-0.023	-0.033
	(-4.80)	(-8.07)	(-7.89)	-53.01	-49.74	-39.97	(-0.99)	(-0.54)	(-0.99)
Male	-0.157***	-0.137***	-0.236***	5.826***	4.910***	5.960***	0.139***	0.092***	0.104***
	(-8.35)	(-5.60)	(-10.34)	(426.09)	-278.21	-358.71	(12)	-6.62	-7.87
Constant	-1.428***	-1.040***	-1.046***	22.451***	21.183***	16.678***	0.592***	0.554***	0.536***
	(-20.99)	(-12.89)	(-15.59)	(456.95)	(356.27)	(337.06)	(15.01)	(12.74)	(15.82)
1<MW<2	2006	2009	2011	2006	2009	2011	2006	2009	2011
Income	-0.174***	-0.189***	-0.070**	1.789***	0.727***	1.996***			
	(-6.70)	(-7.38)	(-2.85)	-91.46	-36.26	-109.95			
Hours of work	0.007***	0.008***	0.013***						
	-9.42	-10.86	-20.23						
Mid-age	-0.097***	-0.086***	-0.118***	-0.226***	0.174***	0.438***	0.014	0.008	0.012
	(-4.86)	(-4.43)	(-6.25)	(-15.58)	-11.7	-32.27	-1	-0.54	-0.9
Old	-0.414***	-0.238***	-0.251***	-0.408***	0.070***	0.009	0.02	0.025	0.011
	(-22.69)	(-13.66)	(-15.13)	(-30.00)	-5.2	-0.79	-1.46	-1.88	-0.94
Low education	-0.416***	-0.415***	-0.269***	2.819***	1.696***	2.673***	-0.145***	-0.130***	-0.160***
	(-11.59)	(-12.14)	(-9.62)	(115.73)	(68.25)	(138.45)	(-6.13)	(-5.44)	(-8.72)
Male	0.017	0.046**	0.006	2.071***	1.682***	2.775***	0.034**	0.030**	0.039***
	(1.04)	(2.97)	(0.42)	(166.15)	(140.21)	(266.47)	(2.79)	(2.61)	(3.85)
Constant	1.026***	0.736***	0.570***	40.090***	41.057***	36.883***	1.472***	1.448***	1.496***
	(16.99)	(12.38)	)10.96=	(1065.41)	(1071.31)	(1102.61)	(62.18)	(59.88)	(79.69)

This table shows the coefficients obtained from the conditional mixed process estimator that simultaneously fits self-reported contribution, hours of work and income as a fraction of the minimum wage measured from 2006, 2009 and 2011 Chilean Household Surveys. The self-reported contribution is analyzed with a probit model, and hours of work and income are In the first panel, the sample is restricted to workers with labor income below the minimum wage. In the second panel, the sample is restricted to workers with labor income above the minimum wage and below two times the minium wage.

Table 7: Crowding out elasticity of pension assets

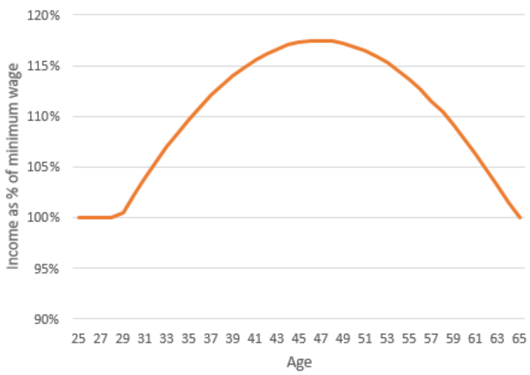
This table summarizes the estimated long-run discount factor (δ) and the parameter that controls the marginal utility of consumption before retirement (γ) explain different moments that can be estimated from the data. Moments include the estimated crowding out elasticity of minimum pension benefits on pension assets accumulation, the estimated effect on the fraction of time contributing to the system and the average replacement rate before the reform. Results are calculated by comparing hyperbolic discounting and exponential time preferences. Newey-West t statistics are shown in parentheses.

Moments fit	Panel A: Baseline estimated elasticity				Panel B: Replacement rate and time on contribution			
	Hyperbolic discounting		Exponential discounting		Hyperbolic discounting		Exponential discounting	
	Male	Female	Male	Female	Male	Female	Male	Female
Long-run discount factor (δ)	0.80	0.87	0.77	0.80	0.77	0.87	0.73	0.87
					(101.81)	(3.56)	(74.06)	(5.83)
Marginal utility of consumption before retirement (γ)	0.50	0.53	0.57	0.43	0.40	0.60	0.40	0.47
					(0.70)	(1.72)	(3.12)	(3.59)
Elasticity (ε)	-0.14	-0.15	-0.15	-0.15	0.03	-0.02	-0.05	-0.19
Moments fit	Panel C: Elasticity and replacement rate				Panel D: Elasticity and time on contribution			
	Hyperbolic discounting		Exponential discounting		Hyperbolic discounting		Exponential discounting	
	Male	Female	Male	Female	Male	Female	Male	Female
Long-run discount factor (δ)	0.80	0.87	0.77	0.87	0.70	0.87	0.70	0.87
	(220.25)	(0.56)	(122.91)	(7.63)	(12.41)	(7.11)	(5.22)	(3.79)
Marginal utility of consumption before retirement (γ)	0.40	0.47	0.40	0.47	0.50	0.60	0.40	0.47
	(2.81)	(0.15)	(4.09)	(5.07)	(1.99)	(3.28)	(0.18)	(2.57)
Elasticity (ε)	-0.16	-0.19	-0.18	-0.25	-0.16	0.01	-0.05	-0.38

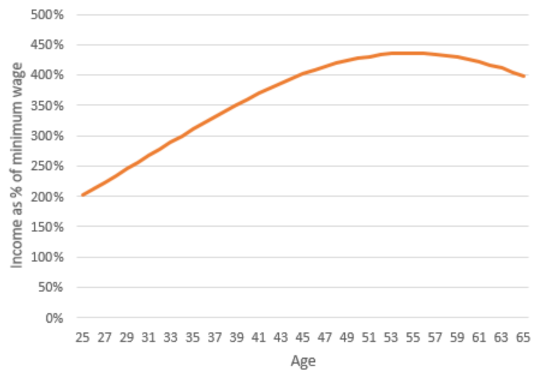
Table 8: Model parameters

This table contains the model parameters.

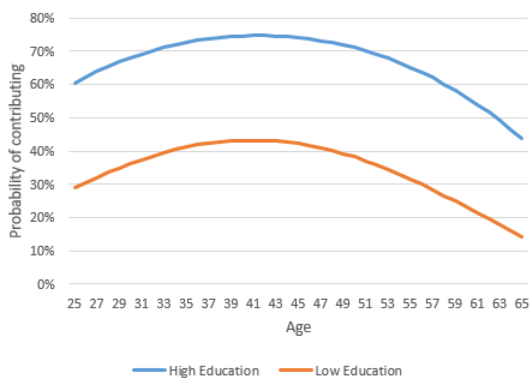
	Parameter	Note
y_l	1	Income cut-offs in the public health fund, as a fraction of the minimum wage
y_m	1.46	
r	2.5%	Real interest rate on liquid savings
r^*	3.5%	Real interest rate on pensin savings
$\bar{\beta}$	0.5	Short term parameter of quasi-hyperbolic discount function (Laibson et al., 2023)
θ	0.07	Mandatory health contribution
τ	0.1	Mandatory pension contribution
v	0.5	Parameter that controls marginal utility of consumption at retirement (square-root utility)
p_l	0.41	Minimum pension (PBS) as a fraction of the minimum wage in May 2011
p_m	1.40	Maximum pension threshold (APS) as a fraction of the minimum wage in May 2011
$\bar{y}$	8.18	Maximum taxable income as a fraction of the minimum wage
Δ	17%	Legal social security contributions as a fraction of income



(a) Estimated income profile of low education worker



(b) Estimated income profile of high education worker



(c) Predicted probability of contribution to the pension system

Figure 10: Expected life-cycle income profile and probability of contribution by educational group
Figure plots the estimated life-cycle income profile of an average low education worker, presented as a percentage of the minimum wage. Expected income is calculated from a cross-sectional regression that includes age and age-squared as control variables. Regressions are estimated by subsamples of low and high educational. In Panel (a), the income profile of workers with low education is presented, including the lower bound imposed by the minimum wage. In Panel (b), the income profile of high education workers is documented. In Panel (c), the life-cycle profile of the probability of contribution to the pension system of workers with low and high education are presented. Estimated probabilities are obtained from a probit model, where the outcome variable is a dummy variable that measures self-reported contribution to the pension system, and the explanatory variables are age and age-squared. All estimations are conducted on the 2006 National Socioeconomic Characterization Survey (CASEN).

[Life-cycle health shock probability]

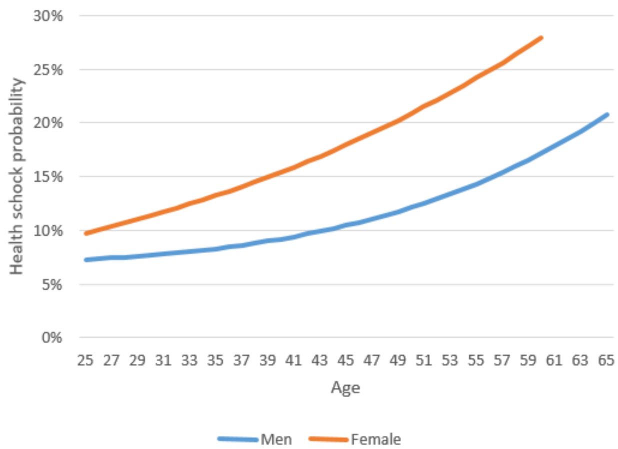


Figure plots the life-cycle health shock probability (p_t) for men and women. The health shock probabilites are obtained from a Probit regression on men who answer "yes" to the question "Did you have any health problem or accident during the last three months?" predicted by age and age-squared in the 2006 National Socioeconomic Characterization Survey.

A Appendix: Model Solution

A.1 Last period Solution

When workers reach retirement they solve a simple optimization problem:

$$V_T = \max_{C_T, h_T^f} \quad U(C_T) + \beta_{T-1,T} E\left[F(W_T^P, W_T, W_T^{\varepsilon}, r_T^*)\right] + \lambda \left(y_T - c_T + W_T\right) \tag{9}$$

$$W_T^P = \left(W_{T-1}^P + \kappa_t \left(h_T^f\right)\right)(1 + r_T^*)$$
$$W_T = \left(W_{T-1} - C_T - \varsigma_T \left(h_T^f\right)\right)(1 + r)$$
$$W_T^{\varepsilon} = \left(\left(W_{T-1} - C_T - \varsigma_T \left(h_T^f\right)\right)(1 + r) - \varepsilon_{t+1}\left(h_T^f\right)\right)$$

The first order conditions on the Lagrangian can be stated as a below:

$$\frac{\partial U(C_T)}{\partial C_T} + \frac{\partial F}{\partial W_T}\frac{\partial W_T}{\partial C_T} + \lambda = 0$$

$$\frac{\partial F}{\partial W_T}\frac{\partial W_T}{\partial h_T^f} + \frac{\partial F}{\partial W_T^P}\frac{\partial W_T^P}{\partial h_T^f} - \lambda\frac{\partial W_T}{\partial h_T^f} = 0$$

Given the assumption in the model, of utility at retirement depending on pension and liquid wealth. Marginal utility at retirement on liquid wealth without experiencing the shock is given by:

$$\frac{\partial F}{\partial W_T} = \alpha\left(\left(p_l + \frac{p_l}{p_m}\frac{W_T^P}{a(r_T^*)}\right)^v + \left(\frac{W_T}{a(r_T^*)}\right)^{1-v}\right)^{\alpha-1}\left((1-v)\left(\frac{W_T}{a(r_T^*)}\right)^{-v}\frac{1}{a(r_T^*)}\right)$$

Marginal utility in case of facing the shocks is given by:

$$\frac{\partial F}{\partial W_T^\varepsilon} = \gamma\left(\left(p_l + \frac{p_l}{p_m}\frac{W_T^P}{a(r_T^*)}\right)^v + \left(\frac{W_T^\varepsilon}{a(r_T^*)}\right)^{1-v}\right)^{\gamma-1}\left((1-v)\left(\frac{W_T^\varepsilon}{a(r_T^*)}\right)^{-v}\frac{1}{a(r_T^*)}\right)$$

Marginal utility at retirement on pension wealth and no health shock is decomposed by parts:

$$\frac{\partial F}{\partial W_T^P} = \begin{cases} \gamma\left(\left(p_l + \frac{p_l}{p_m}\frac{W_T^P}{a(r_T^*)}\right)^v + \left(\frac{W_T}{a(r_T^*)}\right)^{1-v}\right)^{\gamma-1}\left(v\left(p_l + \frac{p_l}{p_m}\frac{W_T^P}{a(r_T^*)}\right)^{v-1}\frac{p_l}{p_m a(r_T^*)}\right) & 0 \leq \frac{W_T^P}{a(r_T^*)} \leq p_m \\ \gamma\left(\left(\frac{W_T^P}{a(r_T^*)}\right)^v + \left(\frac{W_T}{a(r_T^*)}\right)^{1-v}\right)^{\gamma-1}\left(v\left(\frac{W_T^P}{a(r_T^*)}\right)^{v-1}\frac{1}{a(r_T^*)}\right) & \frac{W_T^P}{a(r_T^*)} > p_m \end{cases}$$

Marginal utility at retirement on pension wealth with a health shock is given by:

$$\frac{\partial F}{\partial W_T^P} = \begin{cases} \gamma\left(\left(p_l + \frac{p_l}{p_m}\frac{W_T^P}{a(r_T^*)}\right)^v + \left(\frac{W_T^\varepsilon}{a(r_T^*)}\right)^{1-v}\right)^{\gamma-1}\left(v\left(p_l + \frac{p_l}{p_m}\frac{W_T^P}{a(r_T^*)}\right)^{\gamma-1}\frac{p_l}{p_m a(r_T^*)}\right) & 0 \leq \frac{W_T^P}{a(r_T^*)} \leq p_m \\ \gamma\left(\left(\frac{W_T^P}{a(r_T^*)}\right)^v + \left(\frac{W_T^\varepsilon}{a(r_T^*)}\right)^{1-v}\right)^{\gamma-1}\left(v\left(\frac{W_T^P}{a(r_T^*)}\right)^{\gamma-1}\frac{1}{a(r_T^*)}\right) & \frac{W_T^P}{a(r_T^*)} > p_m \end{cases}$$

Marginal utility at retirement on liquid wealth is given by:

$$\frac{\partial W_T}{\partial h^f_{T-1}} = -\frac{\partial \varsigma_T}{\partial h^f_T} - \frac{\partial \varepsilon_T}{\partial h^f_T} = -(w_f\theta + w_f\tau)$$

Marginal liquid savings by consumption:

$$\frac{\partial W_T}{\partial C_{T-1}} = -1$$

Marginal value of pension wealth on time worked in the formal sector:

$$\frac{\partial W^P_T}{\partial h^f_T} = w_f\tau$$

A.2 Before the last period Solution

In the period before retirement, the first order conditions with respect to consumption and time worked in formal markets of Equation 1 determine worker's behavior:

$$\frac{\partial U_{T-1}}{\partial C_{T-1}} + \beta_{T-1,T}\left[p_{T-1}\frac{\partial F}{\partial W_T}\frac{\partial W_T}{\partial C_{T-1}} + (1-p_{T-1})\frac{\partial F}{\partial W_T}\frac{\partial W_T}{\partial C_t}\right] = 0$$

$$\beta_{T-1,T}\left[p_{T-1}\left(\frac{\partial F}{\partial W_T}\frac{\partial W_T}{\partial h^f_{T-1}} + \frac{\partial F}{\partial W^P_T}\frac{\partial W^P_T}{\partial h^f_{T-1}}\right) + (1-p_{T-1})\left(\frac{\partial F}{\partial W_T}\frac{\partial W_T}{\partial h^f_{T-1}} + \frac{\partial F}{\partial W^P_T}\frac{\partial W^P_T}{\partial h^f_{T-1}}\right)\right] = 0$$

At the same, wealth at retirement is affected by time worked in the formal labor market:

$$\frac{\partial \tilde{W}_T}{\partial h^f_{T-1}} = \frac{\partial y_{T-1}}{\partial h^f_{T-1}}(1+r) - \frac{\partial \varsigma_{T-1}}{\partial h^f_{T-1}}(1+r) - \frac{\partial \varepsilon_T}{\partial h^f_{T-1}}$$

$$\frac{\partial W_T^P}{\partial h_{T-1}^f} = \begin{cases} \frac{\partial \kappa_t}{\partial h_{T-1}^f}(1+r^*) & if \;\; y_{T-1}^F \leq \bar{y} \\ 0 & if \;\; y_{T-1}^F > \bar{y} \end{cases}$$

Social securty expenditure is directly related to the time worked in the formal labor market, as is shown below:

$$\frac{\partial \varsigma_t}{\partial h_{T-1}^f} = \begin{cases} \frac{\partial y_{T-1}^F}{\partial h_{T-1}^f}\theta + \frac{\partial y_{T-1}^F}{\partial h_{T-1}^f}\tau & if \;\; y_{T-1}^F \leq \bar{y} \\ 0 & if \;\; y_{T-1}^F > \bar{y} \end{cases}$$

The marginal income effect with respect to time worked in the formal labor market is given by:

$$\frac{\partial y_{T-1}^F}{\partial h_{T-1}^f} = w_f$$

Time worked in formal markets can also affect contributions to pension, as far as formal income is lower than maximum's taxable income:

$$\frac{\partial \kappa_t}{\partial h_{T-1}^f} = \begin{cases} w_f\tau & if \;\; y_{T-1}^F \leq \bar{y} \\ 0 & if \;\; y_{T-1}^F > \bar{y} \end{cases}$$

Marginal utility over consumption is given by:

$$\frac{\partial U_{T-1}}{\partial C_{T-1}} = \gamma C_{T-1}^{\gamma-1}$$

Marginal utility at retirement is dependent on liquid wealth, as follows:

$$\frac{\partial F}{\partial W_T} = (1-v)\left(\frac{W_T}{a(r_T^*)}\right)^{-v}\frac{1}{a(r_T^*)}$$

On the other hand, marginal utility at retirement is a picewise function of pension wealth defined on minimum pension rules, as we can see below:

$$\frac{\partial F}{\partial W_T^P} = \begin{cases} v\left(p_l + \frac{p_l}{p_m}\frac{W_T^P}{a(r_T^*)}\right)^{v-1} \frac{p_l}{p_m a(r_T^*)} & 0 \leq \frac{W_T^P}{a(r_T^*)} \leq p_m \\ v\left(\frac{W_T^P}{a(r_T^*)}\right)^{v-1} \frac{1}{a(r_T^*)} & \frac{W_T^P}{a(r_T^*)} > p_m \end{cases}$$

The effect of consuming more before retirement is mainly determined by the interest rate on liquid savings:

$$\frac{\partial W_T}{\partial C_{T-1}} = -(1 + r_{T-1})$$

Out-of-pocket expenses are affected, on the margin, by income cutt-offs at which copayments increase:

$$\frac{\partial \varepsilon_T}{\partial h_{T-1}^f} = \frac{\partial \varepsilon_T}{\partial y_{T-1}^F}\frac{\partial y_{T-1}^F}{\partial h_t^f} = \begin{cases} w_f \varepsilon_l & if\ \ y_{T-1}^{F-} = y_l \\ w_f\left(\varepsilon_m - \varepsilon_l\right) & if\ \ y_{T-1}^{F-} = y_m \\ 0 & otherwise \end{cases}$$

y_{T-1}^{F-} means that derivatives are calculated as formal income approaches the income threshold from the left-hand side.

A.3 Value function interpolation

Given that the minimum pension reform introduces a kink on the value function ($\tilde{V}_t(W_t, W_t^P)$) at the level of pension assets (W_t^P) that provide a pension equals to the minimum offered by the government. I propose to conduct an approximation through ordinary least squares that is estimated iteratively by the following regression:

$$V_t = \lambda_{0,t} + \lambda_{1,t} W + \lambda_{2,t} W^P + \lambda_{3,t} W^2 + \lambda_{4,t} W^{P^2} + \lambda_{5,t} I(W^P < p_l a(r_T^*)) W^P + \lambda_{6,t} I(W^P < p_l a(r_T^*)) W^{P^2} + \xi_t$$

V_t is the value function evaluated in a grid for liquid assets (W) and pension assets (W^P); W^2 and W^{P^2} are the squared value of liquid and pension assets; $I(W^P < p_l a(r_T^*))$ is an indicator function that takes a 1 if pension assets are below the level that self-finance the established minimum level.