Effects of Future Pension Benefits on Pre-retirement Labor Supply: Evidence from Chile

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Abstract

In this paper, I estimate the effect of future pension benefits on pre-retirement labor supply for a representative sample of Chilean workers. Using non-linear patterns in pension benefit formulas and a reform that changed non-contributory pensions, I estimate the effect of pension accrual and expected pension wealth on labor force and contributory-sector participation, labor earnings, and hours worked. I find that the effect is related to the impact of pension accrual on the probability to contribute to the pension system. The effect is heterogeneous, and is concentrated among middle-age workers, low-skilled workers, workers with no savings, and workers with higher financial literacy.

Keywords: Labor supply, pension benefits, financial literacy.

JEL Codes: J26, J32, H21

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1 Introduction

Do workers care about their future pension benefits? Mandatory pension contributions are a special kind of mandated benefit, in which workers must to contribute in the present to be entitled to a benefit in the future. As a result, pension contributions represent an implicit tax on work and their effect on labor supply decisions depends on the strength of the link between current contributions and future benefits.

The empirical literature of labor supply responses to future pension benefits is extensive and focuses on the pension incentives to retire for workers near retirement (Krueger and Pischke, 1992; Krueger and Meyer, 2002). The literature studies the implicit tax on work by using the pension accrual (i.e., the expected gain from contributing to the pension system),[1] and the effect of the expected pension wealth (i.e., the present value of pension entitlements minus contributions) on the probability of retirement. This literature has found that accrual measures have a positive effect on labor supply, while the estimated effect of expected pension wealth on labor supply is not conclusive, since this sign changes depending on the country and specification, and in many cases it is not significant (Gruber and Wise, 1998).

On the other hand, the literature analyzing the effects of future pension benefits on labor supply for workers before retirement age is more scarce. This is explained because young workers face more uncertainty about future pension benefits and may not have enough ability to understand their financial environment (Saez et al., 2012; Lusardi and Mitchell, 2011). As a result, most of the studies related to pre-retirement labor supply focuses on workers who are near retirement age, typically over 50 years, since they face less uncertainty and have a better understanding of the pension system rules (Liebman et al., 2009; Liebman and Luttmer, 2012).

In this paper, I estimate the effects of future pension benefits on individuals' labor market choices before retirement. I use exogenous variation from non-linear patterns in the Chilean pension system and from an unanticipated pension reform undertaken in 2008 to estimate the effects of

[1] Along with the pension accrual, there are other measures to account for the pension incentives to retirement, such as the peak value and the option value (Stock and Wise, 1990).

future pension benefits along four margins of labor supply: labor force participation, contributory-sector participation, labor earnings and hours worked per week. I estimate these effects based on a unique source of data, the Longitudinal Social Protection Survey (LSPS), a representative sample of Chilean workers between 2002 and 2015. Since pension accrual and expected pension wealth are not observable, I use age patterns of contributions and earnings to predict pension incentives for each individual of the sample. Then, I run regressions of labor supply outcomes on pension accrual and expected pension wealth, controlling for observable determinants of labor supply. Thus, my identification assumption is that, after controlling for all observable determinants of labor supply, the changes induced by the pension reform and the non-linear patterns of the Chilean pension system are uncorrelated with unobservable determinants of labor supply decisions (Coile and Gruber, 2001; Liebman et al., 2009).

This paper contributes to the literature of effects of pension benefits on labor supply in three dimensions. First, the paper analyzes the response of workers to future pension benefits over the life-cycle, and thus it gathers evidence about workers' forward-looking behavior. Second, the paper studies a country with a sizable non-contributory sector, and thus it also explores pension incentives to avoid paying pension taxes from switching from contributory to non-contributory jobs. Third, since the LSPS contains a rich set of questions about demographic characteristics, financial assets, and financial literacy, the paper also includes a comprehensive analysis of heterogeneous responses by groups.

Previous studies have evaluated the impact of the 2008 Chilean pension reform on pre-retirement outcomes using the LSPS, and have found effects on labor supply allocation (Attanasio et al., 2011). I build on those studies, yet my approach is different as I do not perform an entire evaluation of the reform. Instead, I use the reform to identify two relevant parameters of labor supply and agents' behavior: the average effect of pension accrual on labor supply and the average effect of expected pension wealth on labor supply.

I find three main empirical results in this paper. First, I find that there is a significant relationship between future pension benefits and pre-retirement labor supply. The effect is concentrated on

the probability that a worker contributes to the pension system. Consistent with forward-looking behavior, the estimation results show that pension accrual has a positive and significant effect on contributory sector participation. On average, a one-standard deviation increase of pension accrual increases the probability of contributing to the pension system by 0.025 on a basis of 0.71. Similarly, the effect of expected pension wealth on contributory sector participation is positive and significant, although relatively small. On average, one-standard deviation increase of the expected pension wealth increases the probability of contributing to the pension system by 0.01 on a basis of 0.71. Although the estimated effect of expected pension wealth is consistent with forward-looking behavior, its sign is the opposite to the expected in the standard life-cycle model setting. The aggregated results do not show responses of labor supply to pension system variables along the labor force participation, labor earnings, and hours worked margins.

Second, estimation results by labor force status show that the change in contributory sector participation is related to an allocation of labor supply between salaried and self-employed jobs, which typically are non contributory. This result is consistent with the literature of mandated benefits that find that in absence of changes in wages, an increase in mandated benefits generates incentives to self-employed workers to switch to salaried jobs, and vice versa (Almeida and Carneiro, 2012).

Third, the estimated effect is heterogeneous across workers. The heterogeneity analysis suggests that the effects of pension accrual and expected pension wealth on contributory-sector labor supply is concentrated on men, workers between 40 and 59 years, and less-educated workers. My results are in line with the idea that future pension benefits affect pre-retirement labor supply, yet the effects are concentrated on workers who have flexibility to move between contributory and non-contributory jobs. Nonetheless, this evidence is suggestive, as the lack of statistical power makes that estimates are obtained with low precision. In addition, heterogeneity analysis suggests that workers who do not have savings are more responsive to changes in future pension benefits, which highlights the importance of the pension system as a way of saving for retirement. Moreover, the analysis also finds that the workers' response to future pension benefits is concentrated on workers with higher levels of financial literacy. In contrast with the aggregated results, I found

positive and significant effects of pension accrual on labor force participation for women and on labor earnings for less educated workers, and negative and significant effects of expected pension wealth on labor force participation for older workers.

The rest of the paper is organized as follows. Section 2 describes the institutional background, while Section 3 describes the data used in this study. Section 4 presents the empirical approach and the estimation results. Finally, Section 5 concludes.

2 Institutional Background

To illustrate the sources of variation I use to identify the effect of pension benefits on pre-retirement labor supply, I discuss some relevant details of the Chilean pension system and the pension reform undertaken in 2008.[2] A description of the formulas for the distributive and the contributory components of the pension system is presented in Appendix A.

Since 1981, the Chilean pension system is a system with three tiers: the contributory, the distributive, and the voluntary. The center of the system is the contributory tier, which is a fully-funded, defined contribution system. All salaried workers must contribute 10 percent of their taxable earnings, which are saved in their individual pension account managed by privately-owned pension funds. Workers face the full nominal pension tax rate as the nominal pension tax rate for employers is zero (Gruber, 1997). Regarding self-employed workers, their contributions were based on a voluntary basis until 2018. After reaching the minimum retirement age, 65 years for men and 60 for women, workers are entitled to an annuity based on their accrued pension savings and on their life expectancy (including survivors). Along the contributory tier, the distributive tier is aimed to reduce income inequality and poverty after retirement. The distributive tier is composed of a minimum pension guarantee and a non-contributory pension targeted to low income population.

The 2008 Chilean pension reform modified the distributive tier of the pension system to pre-

[2]This section is based on Attanasio et al. (2011, 2014) and Joubert (2015).

vent old-age poverty for workers with low attachment to the contributory sector, while generating incentives to contribute. The reform changed both the minimum pension guarantee and the targeted minimum pension. Before 2008, the minimum pension was the *pensión minima garantizada* (PMG) and the non-contributory pension was the *pensión asistencial* (PASIS). After reaching the minimum retirement age, workers with a low self-financed pension were eligible to a benefit equal to the PMG as long as they contributed at least by 20 years, otherwise, they were entitled to a pension benefit equal to the PASIS as long as they belong to the poorest 60 percent of the population. After 2008, the distributive tier became the combination of a targeted minimum pension (*pensión básica solidaria*, PBS) and a contributory pension (*aporte previsional solidario*, APS). The APS tops the PBS with a benefit based on the worker accumulated pension savings, which phases out when the overall benefit reaches the maximum subsidized pension (*pensión máxima con aportes solidarios*, PMAS). In addition, the reform extended pension coverage to retirement-age population in the three lower quintiles of the poverty indicator distribution regardless of the time of contribution. As an important exception, the reform established that workers older than 50 years old by 2008 who were entitled to a minimum pension will receive a pension benefit equal to the maximum between the PMG and the sum of the PBS and APS.

Figure 1 summarizes the changes to the distributive tier of the pension system. The figure presents in the horizontal axis the worker's self-financed pension savings at retirement age and in the vertical axis the present value of expected pension entitlements at retirement age. In an individual account system without a distributive tier, the relationship between those variables lies on the 45 degree line. With a minimum pension, though, there is a difference between the worker's pension savings and the worker's pension entitlements. Before 2008 (gray line), workers with low pension savings received the PMG if they contributed 20 years or more. Otherwise, they received the PASIS if they were eligible based on their income. After 2008 (black line), all low income workers will receive at least the PBS, and their pension income increases as a function of their accumulated pension savings.

Figure 1 also shows the effects of the pension reform on expected pension wealth and on

pension accrual, which are the main source of variation I use to identify the effects of future pension benefits on labor supply. First, expected pension wealth is the present value of expected pension entitlements minus pension contributions (Diamond and Gruber, 1999). Therefore, given a level of self-financed pension savings, the expected pension wealth in Figure 1 is represented by the distance between the gray and black lines to the 45 degree line. Second, the pension accrual is the gain in pension entitlements from contributing one more period to the pension system. Given a level of self-financed pension wealth, the pension accrual is approximated by the slope of the gray and black lines.

As Figure 1 shows, the pension reform changed the expected pension wealth and the pension accrual, depending on the self-financed pension savings. Regarding the pension accrual, before 2008, workers could face a pension accrual of zero if they were entitled to a minimum pension or an assistance pension, while workers with pension savings large enough to buy an annuity of a PMG would face a positive accrual. After 2008, the pension reform sought to generate incentives to contribute, as all contributions increase final pension entitlements. Thus, workers face a positive accrual regardless of their pension savings. Nonetheless, because the APS phases out as pension savings increase, workers with self-financed pension savings lower than the PMAS will face a lower accrual. As a result, pension accrual increased for workers with lower pension savings, decrease for workers who were able to buy an annuity equivalent to a pension between PMG and PMAS before the reform, and does not change for workers with higher pension savings. Similarly, while pension wealth increases for some workers, workers that were entitled to a PMG but had low pension savings faced a reduction on their expected pension wealth.[3]

[3]The pension reform included additional components. For women, there is a subsidy for every child born, and a pension saving compensation upon divorce. For young workers (younger than 35), there is a subsidy on their contribution. A list of the additional elements of the reform is in Attanasio et al. (2011).

3 The data

The dataset I use for this study is Chile's Longitudinal Social Protection Survey (LSPS). The LSPS is a longitudinal survey that collects information of coverage of the pension system and workers characteristics' in six Latin American countries.[4] The Chilean LSPS is the longest survey, following about 16 thousand individuals aged 15 or more for the years 2002, 2004, 2006, 2009, and 2015.[5] Starting in 2004, the LSPS became a national representative survey (68 percent of the sample is linked to pension system's administrative data).

The LSPS includes relevant information to characterize labor supply decisions, expected pension wealth and pension accrual. The survey includes information of demographic characteristics, employment history, contribution to the pension system, type of employment, hours worked, labor earnings, and savings, among others. In addition, the LSPS is linked with administrative records from the pension system, and thus the LSPS for 2015 reports the full monthly contribution history, including taxable income and deductions, and accumulated savings in the person's pension individual account by December 2016. As a result, it is possible to approximate the full history of accumulated pension savings. I adjust by inflation all nominal variables by using an index based on *Unidad de Fomento*, which is a variable used to measure the change in cost of financial assets.

The sample used in this paper is the group of men aged 30 to 64 and women aged 30 to 59, for the years 2004, 2006, 2009, and 2015. I select population older than 30 to mitigate the effects of future changes in schooling and future marriage decisions, which are key variables to determine future pension wealth and are not observable in the data.

3.1 Expected pension wealth and pension accrual

A main challenge in this type of studies is that neither the expected pension wealth nor the pension accrual can be observed in the data. Because of that, I use information from the LSPS and admin-

[4] Brazil, Chile, Colombia, El Salvador, Paraguay, and Uruguay.

[5] There is an additional LSPS survey for 2012. However, problems in data collection caused that the dataset could not be used for statistical inference (Observatorio Previsional, 2016).

istrative records to compute a person's expected pension wealth at retirement age R and his or her pension accrual.

The computation of the expected pension wealth is based on a three-stage algorithm described in Appendix A. First, I compute expected pension savings at retirement age by accumulating the person's current pension savings plus predicted contributions by age. To account for differences in the propensity to contribute, I predict future contributions based on age profiles of the number of months contributed per year (contribution density) and contributory-sector monthly earnings by education-gender groups.[6] To mitigate potential endogeneity issues related to changes in the contribution patterns after the pension reform, I use the contribution patterns based on the 2006 round of the LSPS. Next, I apply the pension system rules to the accumulated pension savings to obtain the expected pension benefits and the present value of expected pension entitlements. Finally, the expected pension wealth is the individual's present value of expected pension entitlements minus his or her contributions to the pension system.

In addition to the expected pension wealth, I also compute the pension accrual as the expected gain from contributing one more period to the pension system. Formally, the pension accrual is defined as

$$AR_i = \frac{\mathbb{E}_a\left(PE_R|\, contribution\ in\ a\right) - \mathbb{E}_a\left(PE_R|\, no\ contribution\ in\ a\right)}{w_a^f}, \tag{1}$$

where $\mathbb{E}_a\left(PE_R|\,\cdot\right)$ is the present value of expected pension entitlements by scenario and w_a^f is the average contributory-sector earnings at age a based on the age profiles defined above. The normalization with respect to expected wages implies that the pension accrual equals the nominal pension tax rate in a pure individual account system, while it differs from the nominal pension tax rate for individuals entitled to minimum pensions.

Although the algorithm used in this paper covers the main characteristics of the pension system, it does not include all its features. In particular, eligibility for minimum pension requires that, at

[6]The group selection was based on gender and educational attainment (primary or less, high school or less, and post-secondary education) because those dimensions are characterized by having different propensities to work in the contributory sector (Perry et al., 2007).

the age of retirement, workers belong to the bottom part of the distribution of poverty scores, a feature that I do not take into account. I assume that workers who were not eligible for a pension were entitled to a minimum pension.

3.2 Summary statistics

Table 1 presents summary statistics for men aged 30 to 64 and women aged 30 to 59 based on the 2009 round of the LSPS. The table shows the distribution of population by demographic characteristics, and within each characteristic, labor market indicators by June 2009 and pension system variables with and without the pension reform of 2008. I include the labor force participation rate, the fraction of contributory-sector employment, average earnings (in logs), and average number hours per week. Regarding pension system variables, I include the median accumulated pension savings by June 2009 (in 2015 CLP millions), the median expected pension wealth (in 2015 CLP millions), and the median pension accrual.

Table 1 shows sizable heterogeneity in labor market indicators and pension system variables across groups. The largest variations occur on contributory-sector participation by class of worker, where the fraction of workers who contribute is larger for salaried workers (85 percent) than for self-employed workers (18 percent). This is in keeping with the fact that contribution to the pension system for self-employed workers was on a voluntary basis. While labor force participation, contributory-sector participation, and earnings tend to exhibit defined patterns across characteristics, differences in the number of hours worked by category tend to be stable across groups.

Consistent with the observed patterns in the propensity to contribute, expected pension wealth exhibits a negative relation with the propensity to work in the contributory sector. For instance, expected pension wealth exhibits a decreasing pattern in the level of education, as more educated workers are more likely to reach higher values of self-financed pensions, which makes them ineligible for the distributive tier of the pension system. This is evident in Figure 2, where I present kernel density estimates for the (log) expected pension wealth by educational attainment in 2009, assigning a value of zero for workers who are not entitled to a non-contributory pension. Since

minimum pensions are more likely to be binding for less-educated workers, the distribution of expected pension wealth shows a higher mass on higher values of expected pension wealth. In contrast, the distribution of expected pension wealth for more educated workers is concentrated at zero.

Table 1 also reports the effect of the changes in the distributive tier on pension system variables. Compared with the no reform scenario, the 2008 pension reform increased the median expected pension wealth from 0 to 3.81 2015 CLP millions, and this change is consistent across groups. The reform also reduced the median pension accrual from 10 to 6.9 percent, as the median worker became eligible to non-contributory pensions. Figure 3 presents the estimated histogram of the pension accrual in 2009 under the pension reform and no pension reform scenarios. In the scenario without reform (solid bars), workers were entitled to either a minimum pension (with an accrual rate of zero) or a self-financed pension (accrual rate of 10 percent). With the pension reform, most of the workers face a positive accrual rate, which can be either the net pension tax rate adjusted by the claw back from the non-contributory pension (6.9 percent) or the nominal pension tax rate (10 percent).[7] Since less educated workers are more likely to be entitled to non-contributory pensions, they are also more likely to face a lower accrual rate.

A relevant feature of the previous results is that, even though differences across groups are used to predict the expected benefits, pension system variables exhibit sizable variation between demographic characteristics. The non-linearity of the pension benefits formulas along with the changes caused by the pension reform of 2008 will provide useful variation to identify the effects of the pension system on labor market outcomes (Coile and Gruber, 2001).

[7]Some workers in the pension reform scenario faces a zero accrual rate because they were born before 1958 and therefore they are entitled to the pre-reform minimum pension.

4 Empirical approach

4.1 Identification strategy

In the empirical analysis of the effects of pension benefits on pre-retirement labor supply, a main concern is the potential correlation between future pension benefits and unobservable determinants of labor supply (Krueger and Pischke, 1992; Liebman et al., 2009). The literature overcomes this concern by using discontinuities from the institutional details of the pension plans (Liebman et al., 2009; Coile and Gruber, 2001), and by using exogenous changes on future pension benefits (Krueger and Pischke, 1992; Gelber et al., 2016; Becerra, 2017). I estimate the causal effect of pension benefits on labor supply based on both non-linearities and exogenous variation of the expected pension wealth and the pension accrual. The Chilean pension system provides both types of variation, and they are likely uncorrelated with worker's unobservable characteristics. Thus, these changes provide useful variation to identify the effect of pension benefits on pre-retirement labor market outcomes.

Using the LSPS, I estimate the relationship between pre-retirement labor supply outcomes, pension accrual, and expected pension wealth by running regressions of the form

$$\begin{aligned} Y_{it} =& \alpha_1 AR_{it} + \alpha_2 \log\left(\mathbb{E}_a PW_R\right)_{it} 1_{\{\mathbb{E}_a PW_R > 0\}} + \alpha_3 1_{\{\mathbb{E}_a PW_R = 0\}} \\ &+ X'_{it}\delta + \theta_i + \theta_t + u_{it}. \end{aligned} \tag{2}$$

In equation (2), Y_{it} is a labor market outcome for person i in year t, AR_{it} is the pension accrual, $\log\left(\mathbb{E}_a PW_R\right)_{it}$ is the log of the expected pension wealth, $1_{\{\cdot\}}$ is the indicator function, and X_{it} denotes a vector of observable characteristics. Regression (2) also includes parameters θ_i and θ_t to control for individual-specific differences and common time shocks across individuals. To capture workers' labor supply responses along several margins of labor supply, I include four labor market outcomes as dependent variable (as reported by June of each year). Selected outcomes are an indicator variable for labor force participation, an indicator variable for contributory-sector

participation, log monthly earnings, and log number of hours worked per week.

The identifying assumption in equation (2) is that, after controlling for observable determinants, unobservable determinants of labor supply decisions are uncorrelated with non-linear patterns of expected pension wealth (Liebman et al., 2009). Since I use demographic and current pension system variables to predict the expected pension wealth and pension accrual (section 3.1), I control flexibly for those variables in regression (2). In particular, I include as dependent variables the interaction of a cubic trend on age with indicators of gender, education, and marital status, and interaction between all those variables. Regarding current pension system variables, I include as controls the person's current pension savings (in logs) and time of contribution. In this way, the remaining variation in expected pension wealth and accrual rates after controlling for observable variables should be driven by the non-linearity from the pension system formulas and by the changes caused by the pension reform.

A Table with summary statistics of the variables included in the regressions is presented in Appendix B.

4.2 Estimation results

Estimates of equation (2) obtained with the panel fixed-effects estimator are presented in Table 2. The rows in the table show regression estimates for the pension accrual and the log expected pension wealth, while each column represents a different regression using as dependent variable one of the labor market outcomes described before. The first column includes the entire sample, and uses as dependent variable an indicator of whether the person is in the labor force. Second column restricts the sample to those employed, and uses as dependent variable an indicator of whether the worker contributes to the pension system. Third and four columns restricts the sample to those employed, and uses as dependent variables the log monthly labor earnings and the number of hours worked per week. Like in the case of expected pension wealth, I account for inflation in labor earnings by using the changes in *Unidad de Fomento*. To mitigate the effects of outliers and misreporting in earnings and hours worked, I trim the top and bottom 1 percent wages each year,

and restrict the sample for the regression of hours worked to workers reporting up to 96 hours per week.

Regression estimates show that the importance of future pension benefits on pre-retirement labor supply for Chile is along the contributory-sector margin. As Table 2 points out, pension accrual and expected pension wealth are not significant variables to explain the behavior of labor force participation, earnings, and hours worked. In contrast, both pension accrual and expected pension wealth are significant in explaining the worker's decision of contribute to the pension system. Consistent with the predictions of the life-cycle theory, pension accrual increases the probability that a worker contributes to the pension system. On average, a one-standard deviation increase in the pension accrual increases the probability that a worker contributes to the pension system by 0.025 on a basis of 0.71.

Similar to the effect of pension accrual, the estimate of expected pension wealth on contributory-sector participation is positive and significant. On average, a one-standard deviation increase in the expected pension wealth increases the probability that a worker contributes to the pension system by 0.01 on a basis of 0.71. Although this result is opposite to the predictions of the life-cycle theory, the literature has found similar results along other margins of labor supply. For instance, Gruber and Wise (1998) show in their study of pension incentives to retire, accrual measures have a positive relationship with the probability of continuing in the labor force. In contrast, results on pension wealth are not conclusive, since the sign and significance of the estimates depend on the country and the econometric specification.

In sum, the estimation results presented in Table 2 indicate that in the case of Chilean workers, labor supply responds to future pension benefits, and the response is along the probability of contributing to the pension system. Consistent with literature studying pension incentives to retire, pension accrual is the relevant variable to explain workers' changes in labor supply, while the effect of pension wealth is rather moderate.

4.2.1 Effects on labor force composition

The estimated effects of future pension benefits on the probability of contributing to the pension system suggest that workers respond to pension taxation by reallocating their labor supply from taxable to non-taxable jobs. Next, I examine the type of non-taxable jobs that workers choose as response of changes in pension accrual and pension wealth. I restrict the sample to labor force population and run versions of equation (2) using as dependent variable indicators of whether a person reports being a salaried worker, whether a person reports being a self-employed worker, and whether the person reports being unemployed by June of each year.

Estimation results are presented in Table 3. Estimates show significant effects of pension accrual on the probability of working as salaried worker and the probability of working as self-employed. On average, a one-standard deviation increase in pension accrual increases the probability of working as salaried worker by 0.025 on a basis of 0.586, while decreases the probability of working as salaried worker by 0.023 on a basis of 0.24. As I discussed in Section 2, self-employed workers contribute to the pension system on a voluntary basis, and only a small fraction of self-employed workers contribute. Thus, a change in the accrual rate affects the opportunity costs of working as self-employed rather than salaried worker. Similar results have been found by Almeida and Carneiro (2012) and Becerra (2017) who found that changes in mandated benefits generate that workers reallocate their labor supply between non-contributory (informal) and contributory (formal) jobs.

4.2.2 Heterogeneity analysis

The estimation results presented above suggest that pension accrual rate and expected pension wealth have an effect on pre-retirement labor supply. In particular, these variables have an effect on contributory-sector participation, and do not have an effect on labor force participation, monthly earnings and hours worked. Next, I study the differential effects that pension accrual and expected pension wealth may have by workers' characteristics, namely, gender, age, educational attainment, saving behavior, and financial literacy.

I analize the effects of pension accrual and expected pension wealth by groups by running regressions of the form

$$Y_{it} = \sum_{g \in G} \left(\gamma_{1g} AR_{it} + \gamma_{2g} \log \left(\mathbb{E}_a PW_R \right)_{it} 1_{\{\mathbb{E}_a PW_R > 0\}} + \gamma_{3g} 1_{\{\mathbb{E}_a PW_R = 0\}} \right) + X'_{it}\mu + \gamma_i + \gamma_t + v_{it}, \tag{3}$$

where the variables are defined as in equation (2). Index g represents mutually exclusive categories. Therefore, in the estimation of equation (3) I allow that the effects of pension accrual and expected pension wealth change by category.

The first set of results is on the basis of gender. Table 1 (Section 3.2) shows that women tend to have a lower attachment to the labor force, which causes that they have lower pension savings and are more likely to be entitled to non-contributory pensions than men. Given these differences, it is possible that women are more sensitive to men to changes in expected pension wealth.

Table 4 presents the estimation results of equation (3) for the full sample. In contrast to the baseline results, labor supply responses to pension incentives are along the labor force participation and the contributory-sector participation margins. The pension accrual is a relevant variable in the labor force participation decision for women, where a one-standard deviation increase in pension accrual increases labor force participation by 0.016 on a basis of 0.65, while its effect is not significant for men. Moreover, results also indicate that expected pension wealth is not a significant determinant of labor force participation. Regarding responses along the contributory-sector margin, the pension accrual is positive and significant for both men and women. On average, a one-standard deviation increase in pension accrual increases the probability of working in the contributory sector by 0.027 on a basis of 0.71 for men and by 0.023 on a basis of 0.7 for women. Although the estimated effect of pension accrual is larger for men, lack of statistical power prevents me from concluding whether there are differences between groups. On the other hand, the aggregated effect of expected pension accrual is driven by men.

The second set of results is on the basis of age, which is a relevant variable when analyzing the

effects of pension incentives (Attanasio and Rohwedder, 2003). Workers may respond differently to changes in their pension wealth and pension accrual over their life cycle, as they face different time horizons to adjust to those changes. A common perception with respect to age is that effects of pension variables on labor supply of young workers should be small, because pension benefits are far in the future and there is more uncertainty about future pension benefits (Saez et al., 2012).

The results of the estimation by age groups are presented in Table 5. The results show that workers show differential responses over the workers' life cycle. Regarding contributory-sector participation, estimates show that the effects of expected pension wealth are driven by the response of workers younger than 50. In turn, the effect of pension accrual on contributory-sector participation is driven by workers aged 40 to 50. In addition, workers near retirement (60 to 64) did not change their contribution patterns as result of changes in pension system variables. Consistent with evidence indicating that workers become more aware of their pension benefits over age (Liebman and Luttmer, 2012), the largest estimated effect of pension accrual on contributory-sector participation is for workers aged 50 to 59. Nonetheless, the differences with respect to other groups are not statistically significant.

Even though the aggregated results show no effect of expected pension wealth on labor force participation (Table 2), the response of labor force participation to pension system variables show differential responses by age. The estimates show that pension incentives to participate in the labor force are negative and significant for workers near to the minimum retirement age. In particular, an increase in expected pension wealth reduces the probability that workers older than 50 participates in the labor force. On average, a one-standard deviation increase of the (log) expected pension wealth reduces the probability of participating in the labor force by 0.016 on a basis of 0.72 for population aged 50 to 59 and by 0.033 on a basis of 0.75 for population aged 60 to 64.

The third set of results is on the basis of educational attainment. Workers with higher gains from working in the contributory sector are less sensitive to future pension benefits along the contribution margin because their gains are large enough and do not discourage them to contribute (Becerra, 2017). Since the gains and costs from contributing to the pension system are not directly

observable, I use educational attainment as a dimension that implicitly characterizes workers with different propensity to participate in the contributory sector. Consistent with this observation, summary statistics presented in Section 3.2 show that more educated workers are more likely to participate in the contributory sector, tend to have a lower expected pension wealth and higher pension accrual than less educated workers.

The estimation results by educational attainment are presented in Table 6. The estimates show that the response of contributory-sector participation to changes in pension system variables is driven by the response of less educated workers. Pension accrual is positive and significant for workers with high school education or less, while it is not significant for workers with more than high school education. The magnitude of the estimated effects are stronger on workers with primary education than workers with high school education, yet the differences are not statistically significant. In turn, the results of expected pension wealth on contributory-sector participation is driven by workers with high school education.

In contrast to other results throughout the paper, results presented in Table 6 show a positive and significant effect of pension accrual on labor earnings for workers with primary education. On average, a one-percent increase in the pension accrual increases monthly earnings of less educated workers by 0.98 percent. Since the estimates of pension accrual on hours worked per week are small and not significant, the positive effect on earnings suggest that the effect of pension accrual on monthly earnings is related to an increase of earnings per hour reported by less educated workers. This effect may be explained either by actual increases in earnings that workers may receive by switching to the contributory sector, or by a better reporting of taxable income, since there are gains from reporting truthfully.

The fourth set of results is on the basis of saving behavior. Savings are a key element of an individual's labor supply allocation. For instance, financial constraints have been one of the determinants explaining the responses along the retirement margin as soon as individuals reach the minimum retirement age (Gruber and Wise, 1998). I use the information about the use of savings decisions reported in the LSPS, and construct and indicator variable of whether a person reports to

save in at least one type of saving instrument.[8] About 24 percent of the sample reports having at least one type of saving instrument. A concern in this part of the analysis is whether workers may change their saving behavior due to the pension reform of 2008. Nonetheless, I found no statistical evidence that pension accrual or expected pension wealth has an effect on the probability that individuals save. I also run additional regressions using information of savings decisions in 2006 only and I find similar results to the presented below.[9]

The estimation results by use of financial assets are presented in Table 7. Like in previous results, the effect of pension accrual and expected pension wealth is concentrated along the contributory-sector participation margin. The results show that the effect of pension accrual and expected pension wealth is driven by the response of workers with no savings, suggesting that workers with low savings are more sensitive to changes in the pension system variables. For instance, individuals with limited access to financial assets for saving for retirement can use working in the contributory sector as a way for saving.

Finally, the fifth set of results is on the basis of financial literacy. A critique to the predictions of the life-cycle model is that workers may lack of information and of financial knowledge to fully understand the extent of changes in future pension benefits (Lusardi and Mitchell, 2009). Consistent with this idea, recent literature has found that population with higher financial literacy tend to be better planners for retirement and are more likely to respond to changes in their pension plans than population with low financial literacy (Lusardi and Mitchell, 2011; Chetty et al., 2014).

The rounds of 2006 and 2009 of the LSPS includes questions to asses an individual's level of financial literacy, developed previously in the United States Health and Retirement Study (HRS). The full set of questions includes 12 questions about basic numeracy, more sophisticated financial knowledge, and their knowledge of the pension system (Behrman et al., 2012). In what follows, I use the 6 questions related to numeracy and financial knowledge, and test whether the response of workers to pension system variables depends on their level of financial literacy. To mitigate the

[8] Included instruments are designated saving accounts for buying a house, for retirement, a bank savings account, certificate of deposit, mutual funds, stocks or bonds, loans to persons, and others

[9] Results are available upon request.

effects that the pension reform may have on the measures of financial literacy, I restrict the sample to workers who answered financial literacy questions in 2006.

The estimation results by level of financial literacy are presented in Table 8. I group workers depending on the number of correct answers to the 6 questions. Workers with low financial literacy are those with zero correct answers, including those who answered "do not know" (20 percent of the sample in 2006). Similarly, workers with medium financial literacy are those who answered correctly 1 to 3 questions (50 percent of the sample), while workers with high financial literacy answered correctly 4 or more questions (30 percent of the sample). Results in Table 8 show that, although individuals with low financial literacy exhibit the lowest labor force participation and contributory-sector participation, they do not respond to changes in pension accrual or expected pension wealth. Contributory-sector participation is sensitive to changes in pension accrual for individuals with medium and high financial literacy. In fact, the largest estimate for the effect of pension accrual is found for workers with high financial literacy, although the differences are not statistically significant. Regarding expected pension wealth, the effects are driven by the response of workers with high financial literacy. Overall, the results are consistent with the idea that the response to pension system variables depends on individuals' ability to understand their financial environment.

5 Conclusions

In this paper, I analyze the effect of future pension benefits on pre-retirement labor supply decisions for Chile. Using a representative longitudinal dataset covering determinants of labor supply and future pension benefits, I estimate the effects of both pension accrual and expected pension wealth on a sample of Chilean workers between 2002 and 2015. To mitigate potential endogeneity concerns between the future pension benefits and current labor supply, I follow Coile and Gruber (2001) and Liebman et al. (2009) and identify the effects of future pension benefits on labor market outcomes by using non-linear patterns from pension benefit formulas and the exogenous variation

caused by a pension reform undertaken in 2008.

Overall, I find that future pension benefits do affect pre-retirement labor supply and this effect is concentrated along the contributory-sector participation margin. The most relevant variable across the different specifications is the pension accrual. Consistent with forward-looking behavior, pension accrual has a positive effect on contributory-sector participation. With respect to the expected pension wealth, it has a positive and significant effect on contributory-sector participation, although its magnitude is relatively small.

In addition, the estimated effects indicates that, similar to the results of Almeida and Carneiro (2012) for mandated benefits, in absence of changes in wages, the changes in future pension benefits may generate incentives for self-employed workers (typically non-contributory jobs) to switch to salaried (contributory) jobs. Moreover, although the results are concentrated on contributory-sector participation, heterogeneity analysis shows that the effects of pension system variables are concentrated on workers with lower attachment to the contributory sector, and workers with a basic understanding of their financial environment.

In sum, in this paper I find evidence supporting the existence of a link between future pension benefits and labor supply before retirement. Although the effect is concentrated along the probability of contributing to the pension system, a less relevant dimension for developed economies, it shows that workers as young as 30 years respond to future pension benefits. For developing economies, though, this is a relevant margin to account for when designing pension programs. In particular, pension programs with positive accrual effects may have better effects on contribution probability.

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Table 1: Summary statistics, 2009

$N = 10,043$	Share of total	Labor force participation	Contributory sector workers	Monthly earnings (log)	Hours Worked per week	Pension system variables (labor force only)				
						Pension savings	Exp. Pension wealth		Pension accrual	
							No reform	Reform	No reform	Reform
						(CLP 2015 millions)				
Total	–	0.76	0.68	12.51	44.63	4.821	0	3.812	0.10	0.069
Gender										
Men	0.51	0.91	0.68	12.63	46.48	6.547	0	2.896	0.10	0.069
Women	0.49	0.61	0.67	12.30	41.48	2.915	0.682	4.952	0	0.069
Age group										
30-39	0.32	0.84	0.75	12.60	44.41	5.568	0	1.710	0.10	0.069
40-49	0.34	0.78	0.69	12.49	44.72	6.588	0	4.144	0.10	0.069
50-59	0.29	0.67	0.59	12.43	44.69	2.361	4.717	8.555	0	0.069
60+	0.06	0.71	0.53	12.39	45.34	0.039	9.784	12.920	0	0.069
Educational attainment										
Primary	0.33	0.67	0.52	12.06	43.62	1.454	2.885	6.391	0	0.069
High School	0.49	0.77	0.69	12.46	45.47	5.236	0	3.536	0.10	0.069
More than HS	0.17	0.91	0.83	13.18	43.99	11.901	0	0	0.10	0.10
Class of worker (employed only)										
Salaried	0.73	–	0.85	12.68	45.30	8.453	0	2.325	0.10	0.069
Self-employed	0.22	–	0.18	12.10	43.77	0.158	3.202	6.791	0	0.069
Other/unpaid	0.05	–	0.39	11.75	38.02	0.550	4.079	7.126	0	0.069

Notes: This table presents summary statistics from labor market outcomes and pension system variables based on LSPS data of 2009. First column presents the distribution of population by gender, age, educational attainment, and class of worker. Columns two to five presents the fraction of workers in the labor force, and within those employed, the fraction that contributes to the pension system, their average earnings, and the average number of hours per week. Columns six to ten focuses on labor force, and presents the median current pension savings, expected pension wealth and pension accrual under the scenarios with and without pension reform.

Source: Author's calculations based on LSPS data.

Table 2: Estimation results

	Dependent variable			
	Labor force participation indicator	Contributory sector job indicator	Monthly earnings (logs)	Hours worked (logs)
Pension accrual	0.167	0.630	0.424	-0.176
	[0.146]	[0.205]***	[0.309]	[0.218]
Expected pension wealth (logs)	0.00302	0.0107	-0.00388	-0.00195
	[0.00405]	[0.00571]*	[0.00671]	[0.00495]
Individuals	14,353	11,705	11,278	11,549
Observations	38,817	26,916	24,929	25,860
Mean dependent variable	0.7849	0.7089	12.5711	3.7576

Notes: This table presents the estimates of equation (1) based on LSPS data. Each column shows estimates of pension accrual and expected pension wealth for a different dependent variable. Robust standard errors (clustered by person) in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Source: Author's calculations based on LSPS data.

Table 3: Estimation results by labor force status

	Dependent variable		
	Salaried job indicator	Self-employed job indicator	Unemployed indicator
Pension accrual	0.688	-0.570	-0.0773
	[0.232]***	[0.201]***	[0.172]
Expected pension wealth (logs)	0.00478	0.000870	-0.00686
	[0.00615]	[0.00502]	[0.00454]
Individuals	12,754	12,754	12,754
Observations	30,864	30,864	30,864
Mean dependent variable	0.5863	0.2403	0.1248

Notes: This table presents the estimates of equation (1) based on LSPS data. Each column shows estimates of pension accrual and expected pension wealth for a different dependent variable. Robust standard errors (clustered by person) in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Source: Author's calculations based on LSPS data.

Table 4: Estimation results by gender

	Dependent variable			
	Labor force participation indicator	Contributory sector job indicator	Monthly earnings (logs)	Hours worked (logs)
Effect of pension accrual				
Men	-0.121	0.687	0.553	-0.140
	[0.159]	[0.244]***	[0.374]	[0.256]
Women	0.390	0.563	0.0498	-0.162
	[0.209]*	[0.300]*	[0.409]	[0.354]
Effect of expected pension wealth (logs)				
Men	0.00315	0.0143	-0.0121	0.00107
	[0.00368]	[0.00669]**	[0.00789]	[0.00557]
Women	0.00533	0.00439	0.0151	-0.00780
	[0.00874]	[0.0106]	[0.0127]	[0.00990]
Individuals	14,353	11,705	11,278	11,549
Observations	38,817	26,916	24,929	25,860
Mean dependent variable				
Men	0.9255	0.7134	12.6760	3.8170
Women	0.6454	0.7019	12.4074	3.6656

Notes: This table presents the estimates of equation (3) based on LSPS data. Each column shows estimates of pension accrual and expected pension wealth for a different dependent variable. Robust standard errors (clustered by person) in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Source: Author's calculations based on LSPS data.

Table 5: Estimation results by age groups

	Dependent variable			
	Labor force participation indicator	Contributory sector job indicator	Monthly earnings (logs)	Hours worked (logs)
Effect of pension accrual				
Age 30-39	0.225	-0.162	0.0695	-0.477
	[0.291]	[0.430]	[0.662]	[0.481]
Age 40-49	0.150	0.568	0.488	-0.00827
	[0.202]	[0.271]**	[0.361]	[0.304]
Age 50-59	0.0683	0.979	0.485	-0.117
	[0.202]	[0.271]***	[0.389]	[0.313]
Age 60-64	0.00916	0.752	-0.312	0.519
	[0.377]	[0.549]	[0.680]	[0.566]
Effect of expected pension wealth (logs)				
Age 30-39	0.00325	0.0182	-0.00494	-0.00247
	[0.00601]	[0.00866]**	[0.00979]	[0.00893]
Age 40-49	0.00233	0.0107	-0.00661	-0.00155
	[0.00467]	[0.00631]*	[0.00739]	[0.00561]
Age 50-59	-0.0166	-0.00611	-0.00429	-0.0105
	[0.00530]***	[0.00759]	[0.00956]	[0.00680]
Age 60-64	-0.0331	-0.0161	-0.00220	0.00340
	[0.00867]***	[0.0115]	[0.0128]	[0.00944]
Individuals	14,353	11,705	11,278	11,549
Observations	38,817	26,916	24,929	25,860
Mean dependent variable				
Age 30-39	0.8296	0.7711	12.6121	3.7652
Age 40-49	0.8031	0.7094	12.5592	3.7623
Age 50-59	0.7237	0.6554	12.5390	3.7407
Age 60-64	0.7547	0.6143	12.5704	3.7671

Notes: This table presents the estimates of equation (3) based on LSPS data. Each column shows estimates of pension accrual and expected pension wealth for a different dependent variable. Robust standard errors (clustered by person) in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Source: Author's calculations based on LSPS data.

Table 6: Estimation results by educational attainment

	Dependent variable			
	Labor force participation indicator	Contributory sector job indicator	Monthly earnings (logs)	Hours worked (logs)
Effect of pension accrual				
Primary	-0.0752	0.715	0.983	-0.0684
	[0.210]	[0.289]**	[0.383]**	[0.348]
High School	0.272	0.590	0.465	-0.183
	[0.189]	[0.265]**	[0.409]	[0.283]
More than HS	0.0963	0.374	-0.950	-0.0921
	[0.311]	[0.402]	[0.648]	[0.438]
Effect of expected pension wealth (logs)				
Primary	0.0119	0.0138	-0.0125	-0.00201
	[0.00825]	[0.0101]	[0.0105]	[0.00834]
High School	-0.00408	0.0148	-0.000123	-0.00316
	[0.00571]	[0.00818]*	[0.00988]	[0.00764]
More than HS	0.0107	-0.00257	-0.00485	-0.00434
	[0.00719]	[0.0121]	[0.0142]	[0.00885]
Individuals	14,353	11,705	11,278	11,549
Observations	38,817	26,916	24,929	25,860
Mean dependent variable				
Primary	0.7026	0.5632	12.1570	3.7310
High School	0.7933	0.7164	12.5229	3.7731
More than HS	0.9019	0.8599	13.1808	3.7552

Notes: This table presents the estimates of equation (3) based on LSPS data. Each column shows estimates of pension accrual and expected pension wealth for a different dependent variable. Robust standard errors (clustered by person) in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Source: Author's calculations based on LSPS data.

Table 7: Estimation results by saving behavior

	Dependent variable			
	Labor force participation indicator	Contributory sector job indicator	Monthly earnings (logs)	Hours worked (logs)
Effect of pension accrual				
No savings	0.243	0.682	0.422	-0.138
	[0.154]	[0.218]***	[0.316]	[0.234]
Savings	-0.161	0.439	0.395	-0.326
	[0.225]	[0.302]	[0.473]	[0.370]
Effect of expected pension wealth (logs)				
No savings	0.00208	0.0113	-0.00361	-0.00298
	[0.00407]	[0.00584]*	[0.00710]	[0.00504]
Savings	0.00682	0.00870	-0.00600	0.00123
	[0.00492]	[0.00684]	[0.00773]	[0.00639]
Individuals	14,353	11,705	11,278	11,549
Observations	38,817	26,916	24,929	25,860
Mean dependent variable				
No assets	0.7624	0.6791	12.5100	3.7555
Assets	0.8560	0.7893	12.7354	3.7630

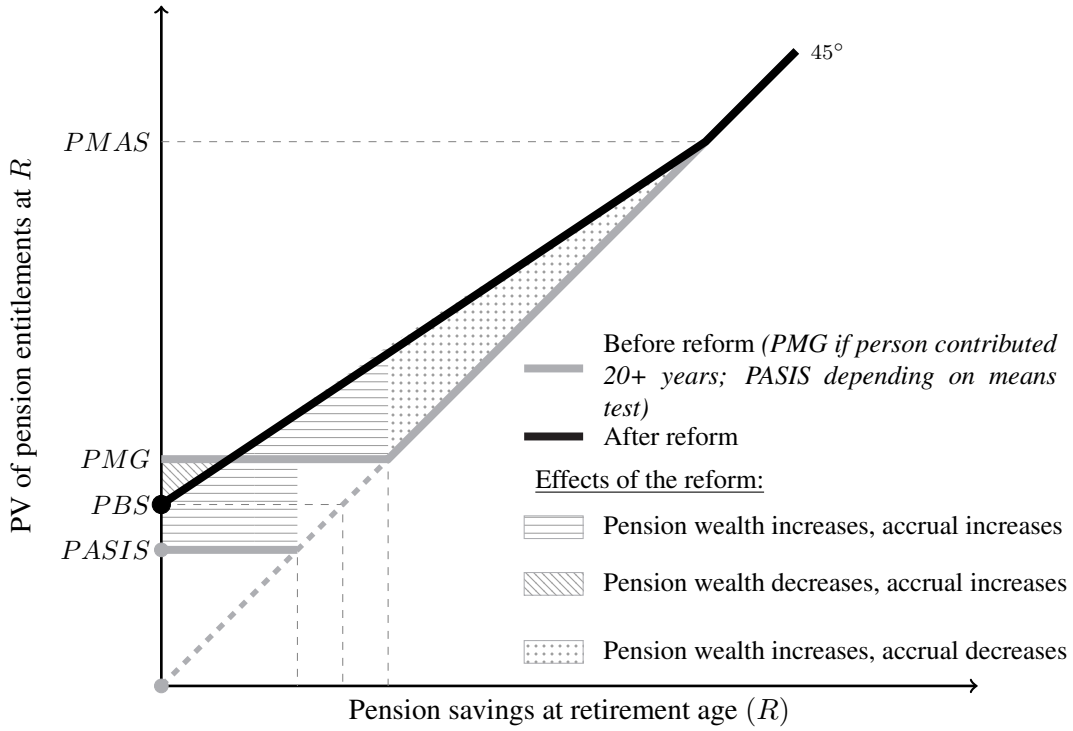
Notes: This table presents the estimates of equation (3) based on LSPS data. Each column shows estimates of pension accrual and expected pension wealth for a different dependent variable. Robust standard errors (clustered by person) in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Source: Author's calculations based on LSPS data.

Table 8: Estimation results by financial literacy

	Dependent variable			
	Labor force participation indicator	Contributory sector job indicator	Monthly earnings (logs)	Hours worked (logs)
Effect of pension accrual				
Low	0.242	0.540	0.686	-0.429
	[0.271]	[0.385]	[0.543]	[0.532]
Medium	0.0492	0.471	-0.0210	-0.0785
	[0.187]	[0.262]*	[0.357]	[0.281]
High	0.356	0.756	0.776	-0.345
	[0.255]	[0.312]**	[0.509]	[0.376]
Effect of expected pension wealth (logs)				
Low	0.00353	0.00489	0.00621	0.00174
	[0.0142]	[0.0147]	[0.0177]	[0.0139]
Medium	0.00194	0.00880	0.00527	-0.00179
	[0.00518]	[0.00833]	[0.00882]	[0.00746]
High	0.00348	0.0187	-0.0188	-0.000476
	[0.00647]	[0.00859]**	[0.0117]	[0.00711]
Individuals	12,749	10,450	10,120	10,325
Observations	36,384	25,162	23,353	24,176
Mean dependent variable				
Low	0.6874	0.6399	12.2368	3.7266
Medium	0.7744	0.6899	12.4900	3.7498
High	0.8598	0.7640	12.8328	3.7756

Notes: This table presents the estimates of equation (3) based on LSPS data. Each column shows estimates of pension accrual and expected pension wealth for a different dependent variable. Robust standard errors (clustered by person) in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Source: Author's calculations based on LSPS data.

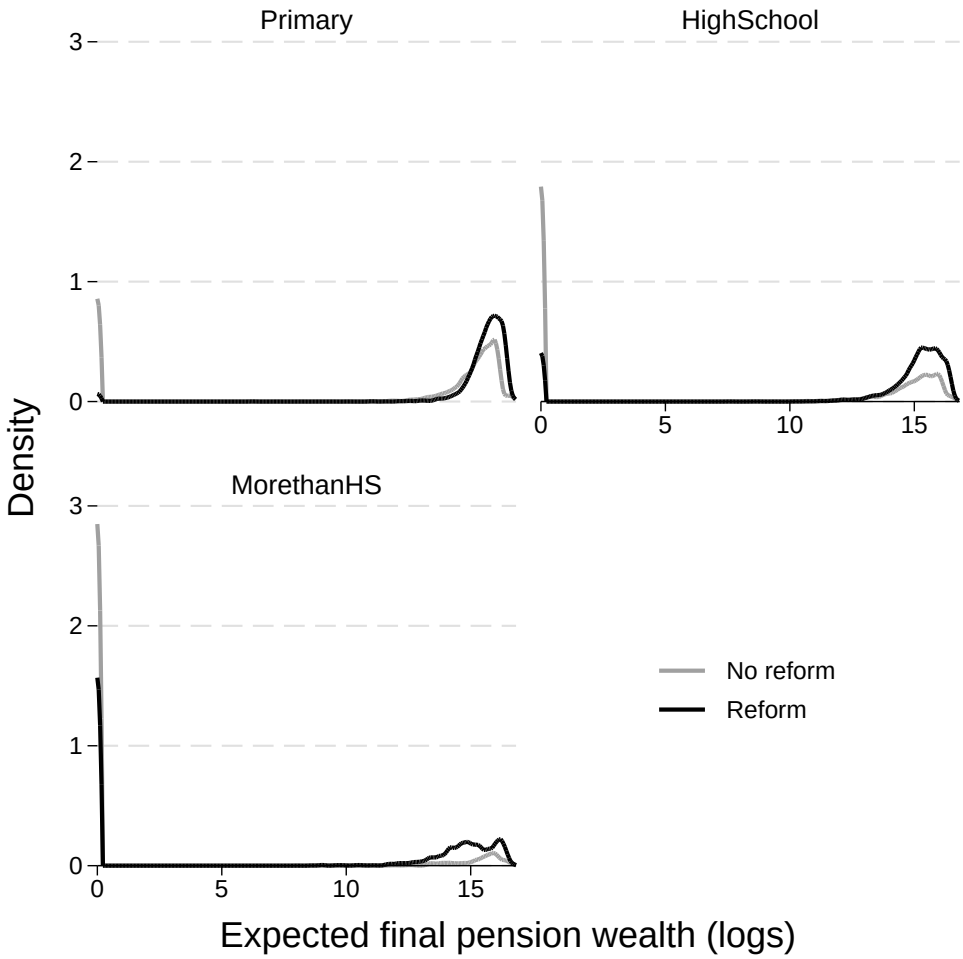
Figure 1: Effects of the reform on pension wealth and pension accrual



Notes: This Figure displays the effects of Chilean pension reform of 2008 on the expected pension wealth and pension accrual. The Figure shows the present value of pension entitlements at the age of retirement (vertical axis) as a function of accumulated pension savings at the age of retirement (horizontal axis). Shadowed areas show the effects of the reform on pension wealth and on pension accrual.

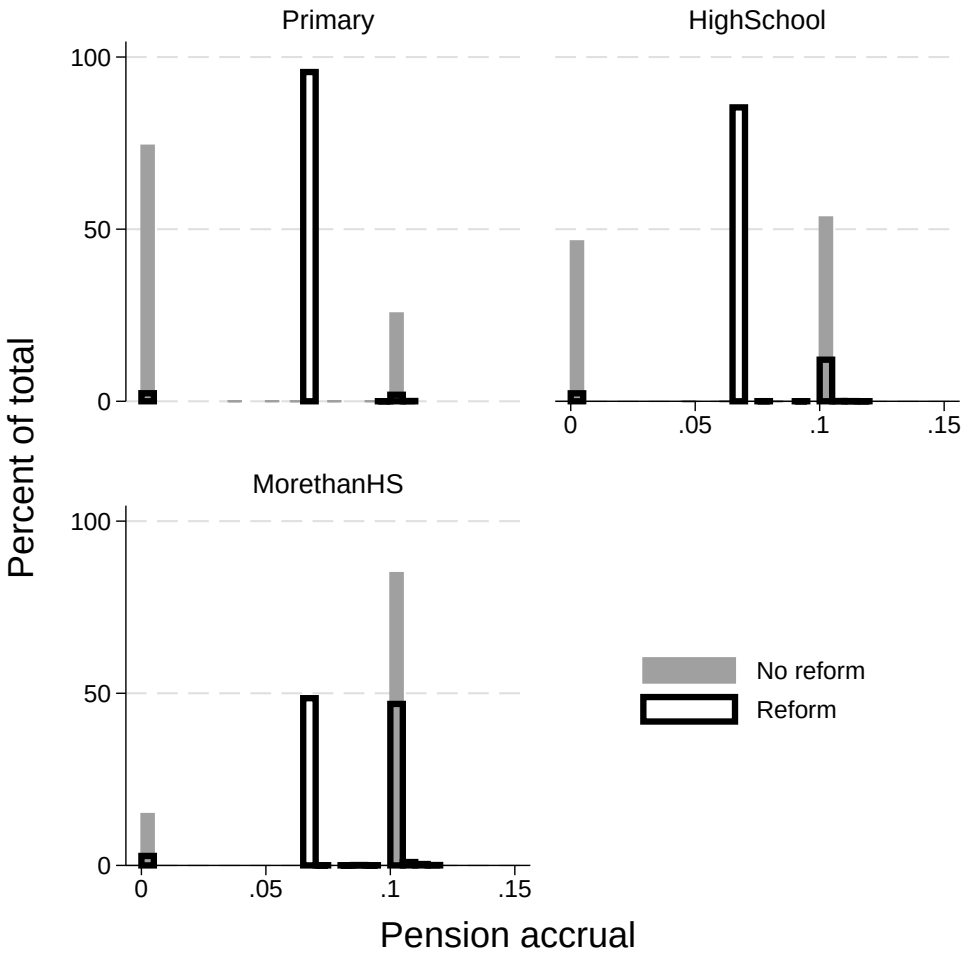
Source: Author's calculations based on Attanasio et al. (2011, 2014).

Figure 2: Kernel density estimates for the distribution expected pension wealth with and without pension reform, 2009



Source: Author's calculations based on LSPS data.

Figure 3: Histogram for pension accrual with and without pension reform, 2009



Source: Author's calculations based on LSPS data.

A Expected pension wealth algorithm

In this appendix, I discuss the details of the calculation of expected pension wealth and pension accrual used throughout the paper. I implement the estimation of the expected pension wealth in a three-step procedure. I compute the accumulated pension savings at retirement age, the expected pension benefit based on those savings, and the pension benefits based on the minimum pension rules of the pension system.

A.1 Expected pension savings at retirement age

The expected pension savings at retirement age is the sum of current pension savings and expected future contributions (plus their returns).

Current pension savings are based on the administrative data from the pension system linked with the LSPS dataset. For each person, the administrative data contain accumulated savings by December 2016, and the contribution history (including taxable income) since the person's initial contribution. Let $PSav_m$ denote accumulated pension savings of a person by month m. With a contribution rate of 10 percent, $PSav_m$ can be obtained as

$$PSav_m = \frac{1}{1 + r_{m+1}}(PSav_{m+1} - 0.1 \times Taxable\ income_{m+1}), \tag{A.1}$$

starting with the accumulated savings in December 2016, while r_{m+1} is the real return of the pension funds in month $m + 1$ as reported by Superintendencia de Pensiones.[10] Starting in 2002, the Chilean pension system allows workers to allocate their contributions in different portfolios. I use as benchmark return the return from the middle-risk portfolio (portfolio C).

Expected contributions to the pension system are based on the age profiles of wages in the contributory sector and number of contributions per year (contribution density). I approach taxable income and number of contributions by age based on predicted values of regression models where the dependent variable is either log wages of full-time contributory-sector workers or contribution

[10] https://www.spensiones.cl/portal/informes/581/w3-propertyvalue-5975.html

density against a quartic trend on age. To account for differences in wages and contribution densities across individuals, I run those regressions separately by gender and educational attainment groups.

Let w_a^f and d_a denote the predicted wage and contribution density for age a (measured in years). Then, a person's expected pension savings and expected time of contribution at retirement age R (denoted $\mathbb{E}_a PSav_R$ and $\mathbb{E}_a H_R$) are computed recursively based on person's current pension savings and time of contribution as

$$\mathbb{E}_a PSav_{a'+1} = (1+r)\,\mathbb{E}_a PSav_{a'} + d_{a'} \times 0.1 w_{a'}^f \tag{A.2}$$

$$\mathbb{E}_a H_{a'+1} = \mathbb{E}_a H_{a'} + d_{a'} \qquad a' = a, \ldots, R, \tag{A.3}$$

where r and a are the real interest rate and the current age of the individual, and $\mathbb{E}_a PSav_a = PSav_a$ and $\mathbb{E}_a H_a = H_a$ are taken from administrative data. I assume a constant real interest rate of $r = 0.04$ and a constant retirement age of $R = 65$.

A.2 Expected pension benefits

Given a value of expected pension savings, the expected self-financed pension benefits are based on the formulas of the Chilean pension system described in Vega (2014). I assume individuals retire under the life annuity system (*renta vitalicia*), and therefore expected self-financed pension benefits are given by the formula

$$\mathbb{E}_a P_R^{sf} = \frac{\mathbb{E}_a PSav_R}{12 \cdot CNU_R}. \tag{A.4}$$

CNU_R (*Capital Necesario Unitario*) is a variable that incorporates life-expectancy of the person and his or her spouse (using the official mortality tables reported by Superintendencia de Pensiones) and expected returns of the pension funds. CNU_R formulas are implemented in a Stata

code described in Vega (2014). I assume a real return of 4 percent.[11]

Next, the expected pension benefits depend on whether the person meets the criteria to be entitled to a minimum pension. The criteria change before and after the pension reform (2008). Before the reform, final pension depended on the self-financed pension, the time of contribution to the system, and whether the person was in the bottom 60 percent of the distribution of a poverty score. Thus, the formula for computing the final pension before the reform is

$$\mathbb{E}_a P_R = \begin{cases} PASIS & \text{if } \mathbb{E}_a P_R^{sf} \leq PASIS \ \wedge \ \mathbb{E}_a H_R < 240 \ \wedge \ p = 1 \\ PMG & \text{if } \mathbb{E}_a P_R^{sf} \leq \ PMG \ \wedge \ \mathbb{E}_a H_R \geq 240 \\ \mathbb{E}_a P_R^{sf} & \text{otherwise,} \end{cases} \tag{A.5}$$

where p is an indicator variable that equals one if the individual belongs to the bottom 60 percent of the poverty score distribution, $PASIS$ is the welfare pension, and PMG is the minimum pension guarantee.

On the other hand, the final pension after the reform is given by

$$\mathbb{E}_a P_R = \begin{cases} PBS + \left(1 - \frac{PBS}{PMaS}\right) \mathbb{E}_a P_R^{sf} & \text{if } \mathbb{E}_a P_R^{sf} \leq PMAS \ \wedge \ p = 1 \\ \mathbb{E}_a P_R^{sf} & \text{otherwise,} \end{cases} \tag{A.6}$$

where PBS is the non-contributory basic pension and $PMAS$ is the maximum subsidized pension. For individuals who were born in before than 1958, they are entitled to the final pension benefit pre-reform if it is larger than their final pension benefit after the reform. For all years, I assume that $PASIS$, PMG, PBS, and $PMAS$ are constant in real terms and set them equal to their 2015 values.[12]

[11] Before the 2008 pension reform, only women were entitled to survivor's pensions. I adjust the CNU_R to account for the change in regulation.

[12] The values used in this simulation are (all values in CLP 2015) $PASIS = 69,373$, $PMG = 123,623$, $PBS = 89,764$, and $PMAS = 291,778$.

A.3 Expected pension wealth and pension accrual

After obtaining the value of the expected final pension benefit, I compute the expected pension entitlements based on the present value of the expected final pension benefits received by the person, i.e.,

$$\mathbb{E}_a PE_R = \left(\frac{1}{1+r}\right)^{R-a} 12 \times CNU_R \times \mathbb{E}_a P_R, \tag{A.7}$$

while the expected pension wealth is the difference between the expected pension entitlements and the expected contributions. Thus, the expected pension wealth is given by the formula,

$$\mathbb{E}_a PW_R = \mathbb{E}_a PE_R - \left(\frac{1}{1+r}\right)^{R-a} \mathbb{E}_a PSav_R. \tag{A.8}$$

Finally, I compute the pension accrual as the change of the expected final pension entitlements for an additional month of contribution at age a. Since an additional month of contribution increases self-financed pension savings at retirement age by $(1+r)^{R-a}\, 0.1 w_a^f$, I compute the expected self-financed pension based on the formula

$$\mathbb{E}_a P_R'^{sf} = \frac{\mathbb{E}_a PSav_R + (1+r)^{R-a}\, 0.1 w_a^f}{12 \cdot CNU_R}. \tag{A.9}$$

Next, using (A.5), (A.6), and (A.7), I obtain the value of the expected pension entitlements with one more month of contributions. Then, the accrual is

$$AR_i = \frac{\mathbb{E}_a\left(PE_R | \, contribution\right) - \mathbb{E}_a\left(PE_R | \, no \; contribution\right)}{w_a^f}. \tag{A.10}$$

Thus, the pension accrual is concentrated on three values: 0.1 for workers who self-finance their own pension, and either 0 (before 2008) or $\left(1 - \frac{PBS}{PMaS}\right) 0.1 = 0.0692$ (after 2008) for workers eligible for the distributive tier of the pension system.

B Additional tables

Table B.1: Summary statistics for the regression sample, 2004-2015

Variable	N	Mean	Standard Deviation	Minimum	Maximum
Dependent variables					
Labor force participation indicator	41,777	0.7549	0.4301	0	1
Cont-sector participation indicator	27,876	0.7008	0.4579	0	1
Monthly earnings (logs)	25,765	12.5608	0.7284	10.2229	14.8451
Hours worked per week (logs)	26,770	3.7516	0.3952	0	4.5643
Pension system variables					
Pension accrual	27,876	0.0602	0.0403	0	0.1193
EPW (logs)	27,876	9.9551	7.3071	0	17.0146
EPW (logs), only positive	17,978	15.2566	0.9712	7.0248	17.0146
EPW equals zero indicator	27,876	0.3475	0.4762	0	1
Current pension savings (log)	27,876	12.4101	6.4260	0	19.5453
Pension savings equal zero	27,876	0.2032	0.4024	0	1
Current years of contribution	27,876	9.4986	8.3274	0	34.1667
Demographic characteristics					
Age	27,876	45.6360	9.3059	30	64
Married	27,876	0.6509	0.4767	0	1
Female	27,876	0.4007	0.4901	0	1
Primary	27,876	0.2761	0.4470	0	1
High School	27,876	0.4908	0.4999	0	1
More than HS	27,876	0.2332	0.4228	0	1

Notes: This table presents summary statistics for the sample used in the estimation of equations (1) and (3). For pension system variables and demographic characteristics, the sample is restricted to labor force only.
Source: Author's calculations based on LSPS data.