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DOES SOCIAL SECURITY AFFECT RETIREMENT AND LABOR SUPPLY? EVIDENCE FROM CHILE

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This paper explores the effects of the social security system on retirement and labor supply decisions. Due to the regulations established by Chilean social security law reform, two social security systems coexist in Chile: the "Pay-As-You-Go" and the individual account system. The coexistence of the systems allows us to better understand the effects of both social security systems on retirement and labor supply. We find that (1) larger benefits in any social security system induce earlier retirement and (2) larger variance of benefits in the individual account system induces later retirement. We do not find major impacts of social security on labor supply of individuals in the labor force.

I. INTRODUCTION

ONE of the characteristics of the labor market around the world during the second half of the twentieth century is a decrease in the labor market participation rate of older individuals. In fact, labor force participation of males aged 60 to 64 in the United States ranged near 80% in 1960 but had decreased to almost 50% by 1995. Significant changes were observed in European countries, too. Belgium and France had a 70% labor force participation in 1960 by males aged 60 to 64. However, these participation rates were only 20% in 1995 (see Gruber and Wise 1997).

An explanation for the decreasing trend in labor force participation is attributed to the existence of a "Pay-As-You-Go" (PAYG) social security system. Social security systems themselves have been a topic of increasing research due to their growing financial problems. Those financial problems have been largely attributed to changes in the age pyramid. Further, the social security financial crisis is exacerbated if social security systems induce earlier retirement or decrease the labor supply per individual.

An alternative to the PAYG system is the individual account (IA) social security system. The effect of switching to an IA system on retirement and labor supply is

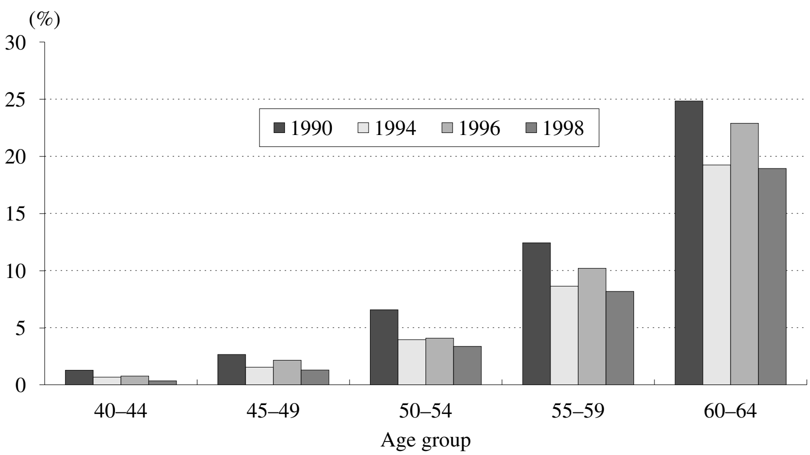
Two anonymous referees provided valuable comments. Any remaining error is completely my own responsibility.

an important policy issue as an increasing number of countries are switching to these systems. However, no clear empirical answer to the effect on retirement and labor supply of IA systems has been produced.

This paper analyzes the effects of the PAYG and IA social security systems on retirement and labor supply using the Chilean experience. The main reason for using Chile as a reference country is that Chile was one of the first countries to move from a PAYG social security system to an IA social security system in 1981. During the 1990s, in contrast with the experience of other countries around the world Chile faced decreases in its retirement rate among individuals aged 60 to 64. In fact, the retirement rate among individuals aged 60 to 64 was 24.4% in 1990 but just 18.8% in 1998. Figure 1 shows the evolution of retirement rates for different age groups during the 1990s. All groups show this decreasing trend related to retirement.

One possible factor that may influence this different retirement rate pattern may be related to the exogenous change in the social security system rather than other characteristics of the economy. As explained below, in Chile, one set of individuals is currently enrolled in the PAYG system while another set is enrolled in the IA system due to regulations established by the 1981 social security law reform. Table I compares retirement between social security systems across different age groups of individuals. The retirement rate for any group is always smaller in the IA system. As individuals become older, the difference in retirement rates becomes larger reaching an 18% difference in the group of individuals aged 60 to 64 years old. This paper will explore carefully the effects of different social security systems over retirement and labor supply and will provide an explanation for these different retirement patterns between social security systems.

Fig. 1. Total Retirement Rates by Age Group, Chile, 1990–98



Source: CASEN survey (various years) and own calculations.

TABLE I

RETIREMENT RATE BY AGE GROUP AND SOCIAL SECURITY SYSTEM, 1998

Age Group	Retirement Rate (%)	
	IA System	PAYG System
45–49	0.6	7.1
50–54	2.6	10.9
55–59	5.8	21.2
60–64	17.5	35.4

Source: 1998 CASEN survey from Chile. This survey aims to describe the socioeconomic characteristics of the Chilean population. It can be obtained from the Chile government.

Another focus of this paper is to distinguish between two possible effects of the social security on labor supply decisions. On one hand, we evaluate the impact of larger social security benefits on labor supply decisions. This case is related to the usual income effect that impacts labor supply decisions. On the other hand, and since we also want to determine the impact of the IA social security systems, we evaluate the impact of the variance of social security benefits on labor supply decisions. In fact, the return of the IA system usually depends on stochastic financial markets rate of return. As individuals cannot perfectly forecast this rate of return, we may hypothesize that individuals retire later so that they accumulate larger assets as a way to protect themselves against negative future shocks on the rate of return of the social security system. Our empirical work will evaluate both hypotheses and will provide magnitudes to evaluate their relevance.

We use the 1998 survey conducted by the Chilean government to monitor the socioeconomic characteristics of the Chilean population (CASEN). The survey has data on individuals in both social security systems and thus will allow us to better understand the impact of both systems on labor supply decisions. There is, however, an identification problem in the estimates. It is possible for individuals to choose between the two different systems. Thus, when unobservable characteristics of the individuals have some influence on the process of choosing, the estimates could be biased if the covariances between the social security variables and unobservable characteristics influencing retirement decisions (or labor supply decisions) are different from zero. To avoid inconsistency in our estimations, we use the regulations of the 1981 social security to provide exogenous variation in our estimates. The 1981 law allows individuals enrolled in 1981 in the old PAYG system to choose between the systems. However, there is a large set of individuals that did not have the choice between systems, and for whom the system choice is exogenous. Some groups can be identified: (1) individuals entering the labor market after the law change were required to enroll in the new IA system, (2) individuals in the armed forces were required to remain in the old PAYG system, and (3) self-employed individuals could choose between enrolling in the IA system or remaining not enrolled in any system at all. We will use the affiliation to those groups as a source of exogenous variation. We find strong evidence that the covariance between the instrumental variable and the labor supply seems to be equal to zero and thus the instruments seem to be valid.

Using the instrumental variable approach, the analysis indicates that an increase of 1% in social security benefits increases the probability of retirement around 0.6%. A second component that affects retirement and labor supply decisions in the IA system is the variance of the benefits. An increase in the variance of return in the IA system decreases retirement. This last effect argues for a precautionary motive as a determinant of retirement timing.

This paper is organized in the following way. Section II discusses the Chilean historical background and both social security systems. Section III presents a theoretical lifecycle model related to social security system, which focuses on the case of random return of social security investments, resembling the privatized Chilean system. Section IV discusses how to test the theoretical predictions and Section V presents the data used in the empirical part of the paper. Section VI discusses the results and Section VII concludes.

II. CHILEAN SOCIAL SECURITY SYSTEM

A. *Historical Background*

Chile introduced its first obligatory social security system in 1925. The system was initially implemented as a mixture between a typical non-funded system and a collective capitalization system. Taxes on workers were used to pay the pensions of retired individuals and any excess funds were accumulated as a reserve for future expenditures.

Initially, funds from the reserve allowed the government to pay part of the benefits but, as the number of retired individuals rose, the funds from the reserve continuously decreased and the system became a fully non-funded PAYG system. The system faced large growth in the number of retired individuals, 209% between 1961 and 1973, while there was only a 53.5% increase in the number of workers during the same period. The government reacted by continuously raising the tax rate over time. After 1973, however, the large increase in the tax rate was not enough to finance the system due to the unfavorable situation of the economy; the period 1973 to 1980 was characterized by a decline in the real wage rate and an increase in unemployment. Those two factors, plus the possible growth of evasion, reduced the revenues of the social security system to levels below those of 1972. As a consequence, in 1981, the Chilean government decided to reform the system and implement a fully funded social security system through individual accounts managed by private institutions.

The timing of the social security reform coincides with important changes in Chile's economic performance. During the last 30 years of the twentieth century, Chile undertook a considerable number of economic reforms, among which we find social security reform, but also trade and corporate taxation reform plus privatization of public firms. Table II shows the evolution of selected macroeconomic variables from 1970 to 1997. As can be seen in the table, this mixture of pro-

TABLE II

CHILEAN ECONOMIC PERFORMANCE, SELECTED VARIABLES, 1970–97

	GDP Growth Rate (%)	Total Value of Equity As % of GDP	Financial Intermediation Ratio As % of GDP	Private Savings As % of GDP	Social Security Savings As % of GDP
1970	2.06	1.09	10.13		0.0
1971	8.96	0.96	12.42		0.0
1972	−1.21	0.67	7.18		0.0
1973	−5.57	2.70	9.84		0.0
1974	0.97	2.25	10.54	6.3	0.0
1975	−12.91	3.44	15.72	−7.2	0.0
1976	3.52	4.30	10.54	−1.4	0.0
1977	9.86	12.63	19.05	−0.1	0.0
1978	8.22	14.01	29.46	1.7	0.0
1979	8.28	20.84	38.11	4.8	0.0
1980	7.94	29.99	50.56	4.6	0.0
1981	6.21	19.33	45.50	9.1	1.4
1982	−13.59	21.75	50.47	7.3	2.8
1983	−2.80	12.92	44.76	8.2	3.4
1984	5.89	11.82	46.43	8.7	4.2
1985	1.97	12.53	49.54	10.1	5.1
1986	5.60	22.70	60.62	12.5	4.4
1987	6.58	26.18	67.20	17.6	5.1
1988	7.29	30.36	75.56	14.2	4.5
1989	10.60	36.62	81.92	17.7	7.0
1990	3.67	45.23	94.89	18.5	9.5
1991	7.97	81.07	131.79	16.7	8.2
1992	12.28	68.79	117.50	15.8	7.7
1993	7.00	97.21	145.86	15.6	8.8
1994	7.88	117.60	165.55	15.9	8.4
1995	8.40	109.03	156.42	16.9	5.1
1996	7.40	89.58	139.61		
1997	6.61	89.47	141.75		

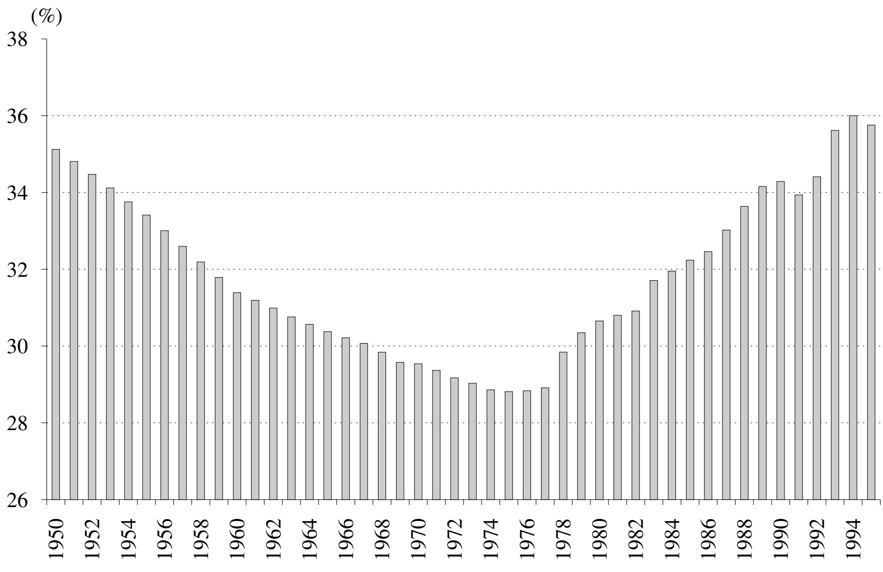
Source: Diaz, Luders, and Wagner (forthcoming).
Note: The financial intermediation ratio is defined as the sum of bank deposits, equities, public debt, and mortgage liabilities.

market reforms seems to have provided an impulse to the Chilean economy that evolved from modest GDP growth rates to an average of 7% in the 1990s. Further, from the table, we may conclude that private savings experienced a significant increase in this period, from negative figures in the 1970s to levels reaching almost 17% by the mid-1990s. Several hypotheses have been suggested to explain this phenomenon (see Hachette 1997), among which we find the emergence of the IA social security system.

There are other possible consequences of the implementation of the fully funded social security system. Literature (see Schmidt-Hebbel 1998) suggests that the large availability of this new source of financial funds available through the IA system may have helped the development of capital markets. Table II, in fact, shows a considerable increase in the financial intermediation ratio (measured as the sum of bank deposits, equities, public debt, and mortgage liabilities) and in the value of equity traded in the Chilean economy since the social security reform. Both data more than doubled since the mid-1970s, suggesting a potentially large impact of the fully funded system.

There is a final interesting characteristic in the Chilean data: the evolution of labor force participation. Since 1950, the social security tax revenue rises from 7% of GDP to almost 15% in 1980. During the same period, the male labor force participation decreased from 26% in 1950 to a minimum of 23% in 1971 and reached

Fig. 2. Evolution of Labor Force Participation in Chile (% of Population)



Source: Diaz, Luders, and Wagner (forthcoming).

24.5% in 1980. However, labor force participation rose considerably after 1981 reaching larger levels than in 1950, as can be seen in Figure 2.

Thus, there are several interesting economic phenomena that might have occurred in response to the implementation of the IA social security system. Literature has focused on private savings and the development of the financial sector but not on labor force participation changes. To fill in this gap, this paper will focus on providing a potential explanation for labor force participation changes, by indicating that the labor force might have been endogenous to the social security system.

B. *The Coexistence of the PAYG and the IA Systems*

The new system has been obligatory for individuals entering the labor force since 1981. However, individuals working in 1981 had the choice between remaining in the old PAYG system or switching to the new IA system. Individuals could switch at any time after 1981, but they could switch just once between systems. Thus, if an individual enrolled in the PAYG system in 1981 chose to switch to the IA system, they could not go back to the old one.[1] Almost 75% of individuals enrolled in the PAYG system in 1981 switched to the new system immediately when the law was enacted.

In this subsection, we focus on explaining the differences between systems that might have influenced the switching decision among individuals. To do so, we first explain how contributions and pensions are determined in both systems.

1. *Contributions*

In both systems, individuals contribute a percentage of their labor income to the social security system. However, the payroll tax rate varies considerably between systems. Further, within the PAYG system there is also variance in the payroll tax rate contributed by affiliates.

Individuals enrolled in the PAYG system might have been affiliated with any of four main institutions: the social security administration (SSA), the private worker pension administration (PRWPA), the public worker pension administration (PUWPA), and the armed forces pension administration (AAFFPA).[2] Some other institutions existed, but their size was smaller than those cited above. The SSA manages the pension funds of unskilled workers of the nonpublic sector. Individuals that remained affiliated to the SSA currently contribute 19.1% of their labor income as social security tax. The PRWPA includes skilled workers of the nonpublic sector and taxes their members at 20.15%. The PUWPA includes the majority of public sector workers and it taxes their members at 19.03%. Finally, the AAFFPA includes as contributors all individuals working in the armed forces. They are taxed

[1] An individual can only switch from the PAYG system to the IA.
[2] There was also a pension administration for the police department.

at 20%. Those taxes were quite large compared to the tax rate faced by an individual enrolled in the new IA system. In fact, individuals in the IA system contribute only 10% of their income as social security tax. None of those tax rates have been changed since 1981.

This tax differential and the subsequent increase in disposable income for individuals switching to the new system may have been very influential on the overall switching from the old to the new system.

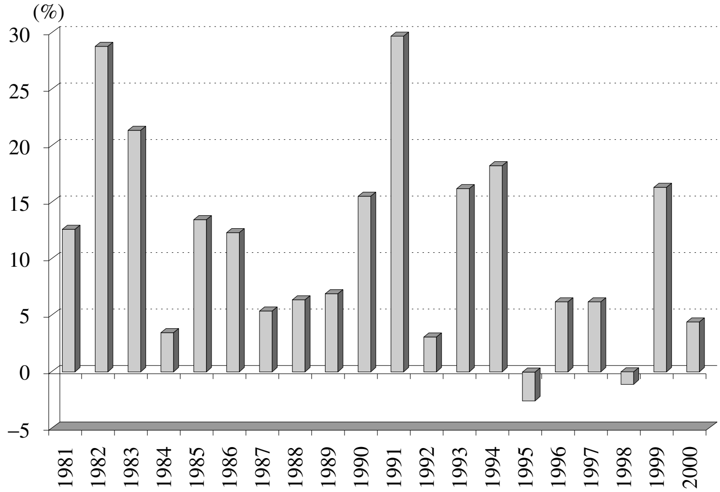
2. *Pensions*

Pensions in the PAYG system are set as a fraction of the average labor income obtained during the last five years of work before retirement. Also, there are additional benefits for some identifiable groups of workers in the PAYG system. If the worker is a widow, she obtains an increase of two years of wage income as base for calculation of pensions, when she is enrolled in the SSA or the PRWPA. Maternity has a similar impact: one year of labor income is added to the calculation base per child. Hard laborers have 10 years of debits in their accounts if they were enrolled in the SSA and worked in the mining sector, but five years of debits if they were enrolled in the SSA and worked in some other sector. Finally, workers on night shifts got five years of subsidy if they were enrolled in the private worker pension administration. Those subsidies were lost if the worker switched to the new pension system.

Pensions across institutions of the PAYG system differ considerably. In fact, when we compare the level of pensions of the four main institutions of the PAYG system, we find that in 1980 (the year before the reform) the average pension receiver of the SSA obtained 46% of the average Chilean pension, while individuals enrolled in the PRWPA obtained 77% of the average and individuals enrolled in the PUWPA received 148% of the average. In the case of the armed forces pension administration, the benefit was 350% of the average Chilean pension (see Arellano 1984). There might be some self-selection in those data since some workers enrolled in the social security administration are unskilled and thus, the difference in pension may be explained, at least in part, by differences in labor income. However, there is also some exogeneity on those benefits. Public workers are not very different from private workers and also the armed forces do not have larger wage incomes than the rest of the economy in general; however, their pensions are considerably larger than the average pension in the PAYG system.

In the IA system, pensions are determined by the amount of money a worker accumulates during her working years. Neither the worker nor the employer pays a social security tax to the state. During their working life, each worker automatically has 10% of their wages deposited by their employer each month in their own individual account. These funds are managed by private corporations denominated as "AFP." These corporations invest the contributions in the financial market and pay

Fig. 3. AFP Return, 1981–2000



Source: Bustamante, Mouchard, and Schulthess (1996).

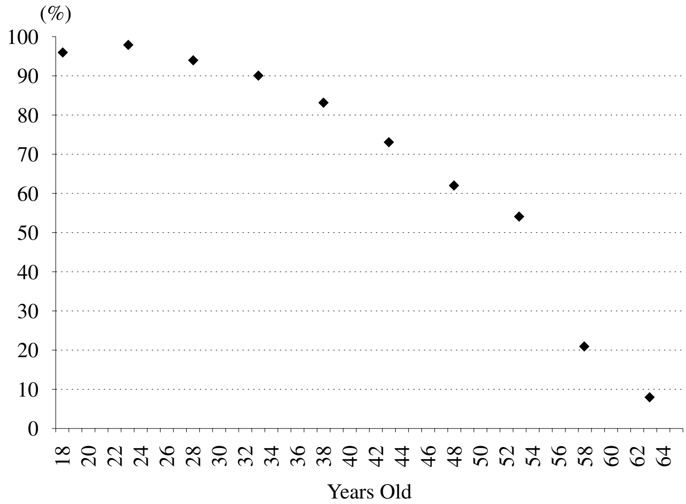
the benefits upon retirement. Individuals, on the other hand, pay commissions for the administration of the fund. Individuals may choose the AFP they enroll in and they can switch among AFPs as they wish. However, individuals cannot distribute their contribution among AFPs.

One of the characteristics of the private system has been the large and highly variable rate of return of the AFPs' investment. Since the implementation of the system in mid-1981 until the end of 2000, the average rate of return was 11.1% with a standard deviation equal to 9.49%. Figure 3 shows the evolution of the return during the period 1981–2000. The standard deviation of the rate of return among different AFPs is quite small, ranging from 0.2% in 1996 to 3.1% in 1981, when the system was first implemented (see Bustamante et al. 1996). Thus, the average rate of return and its evolution represents quite well the evolution of any IA in the private system.

Finally, there were individuals that contributed to the PAYG system and switched to the new system. The way the government handled the contributions already paid to the old system in those cases is to pay a 4% annual real return on contributions to the PAYG system and transfer these funds to the AFPs.

In summary, there currently coexist two social security systems in Chile. In the PAYG system, individuals obtain pensions determined by characteristics established by regulations which depend on past contributions plus adjustments by sex and type of work. In the IA system, affiliates obtain returns from their past contributions. Those returns might be highly volatile as they depend on the rate of return from financial investments.

Fig. 4. Fraction of People Switching to the IA System in 1981 (By Age)



Source: Bustamante, Mouchard, and Schulthess (1996).

3. *Switching to the new system*

The advantage of switching to the new system in 1981 was age dependent. The rationality for this age dependency on the switching decision may be explained by the way pension benefits were determined in both systems. Pensions in the PAYG system were mainly determined by wage income during the last five years of work. Hence, workers had a strong incentive to obtain higher wages during the last part of their working life. In the new system, as the individual has a private account that debits interests over time, they face an incentive to work and accumulate pension funds over all the whole working life. In that scenario, older individuals that did not work hard enough during their working life before 1981 did not have an incentive to switch as the pension they would receive upon retirement would have been lower than the one they would obtain in the PAYG system. On the other hand, a fairly young individual at the time of the social security reform was not negatively influenced, as they did not yet have a working life strategy. In fact, only 8% of enrolled workers aged 63 at the time of the reform switched to the new system while almost 100% of the enrolled workers aged 28 or younger switched to the new system. Figure 4 shows the fraction of enrollees that switched to the new system when the law was implemented as a function of their age.

III. A SIMPLE LIFECYCLE MODEL UNDER UNCERTAINTY

This section will provide a lifecycle model for the social security systems where the retirement date is a chosen variable. Two cases will be considered. First, social security benefits will depend on returns from a risky investment and second, social security benefits will have no uncertainty. We consider both cases because in the Chilean IA social security system, the contributions are invested on a portfolio of assets with a random return, while pensions in the PAYG system do not present this volatility. Hence, the model below with random return will be associated with the IA system while the case with no uncertainty will be associated with the PAYG system.

Consider first the case with random returns. A basic description of the economy is as follows. The economy has three characteristics. First, the economy has a representative individual that lives between age $t = 0$ and $t = T$. They face a working and a retirement period. A social security system is imposed to assure income flows during retirement. Some specialized firms that might be private or public institutions manage those contributions. Second, the economy has two types of assets in the capital market, risk-free assets with return r and risky assets with return z. The return of the latter asset is normally distributed with mean μ and variance σ^2, where $\mu > r$. The individual can borrow or lend at rate r on the capital market; however, only the institution managing the social security contributions can purchase the second asset. Third, there is an insurance market where the representative individual can be fully insured.

The individual works during the first R period of their life and retires for the next $T - R$ periods. To maximize their lifetime welfare function, they choose consumption, hours of labor supplied to the labor market, and their retirement date. Hours supplied to the labor market are restricted by a time limit: there is available one unit of time as endowment. Also the individual faces a social security system that works as follows. It taxes the individual's labor income at period t at rate τ_t and invests those taxes in the risky asset. When the individual retires, the uncertainty on the asset return is resolved. The return of the social security system becomes a retirement fund that is invested at the risk-free interest rate in the capital market. Periodically, between R and T, an amount Φ is debited from the retirement fund and paid to the individual. The amount Φ will be an increasing function of the return z, $\Phi = \Phi(z)$, $\Phi_z > 0$. At the end of period T, the fund reaches a zero value. Hence, the individual uses all her retirement account.

The current utility level is separable over time and it will be defined by additive constant relative risk aversion functions on consumption and hours worked. The specification will be assumed to be $u(c, h) = \frac{c(t, z^t)^{1+\phi}}{1+\phi} - m\frac{h(t, z^t)^{1+\theta}}{1+\theta}$, where $c(t, z^t)$ and $h(t, z^t)$ are current consumption and hours worked. Notice that $\phi > 0$, $\theta < 0$ due to the concavity of the function and m is a parameter of the utility function measuring disutility of work. Also the notation (t, z^t) indicates that the decision variables depend on time and on the realization of z. When $t < R$, the return is not yet realized and the framework does not have uncertainty; therefore, the set of realization for z

could be represented by a degenerated function while when $t > R$, the support of z is non-degenerated. Finally, it is assumed that the individual discounts the future at the rate $\rho > 0$. Thus, the welfare function of the representative individual is $\mathrm{E}[\int_0^R (\frac{c(t, z^t)^{1+\phi}}{1+\phi} - m\frac{h(t, z^t)^{1+\theta}}{1+\theta})e^{-\rho t}dt + \int_R^T (\frac{c(t, z^t)^{1+\phi}}{1+\phi})e^{-\rho t}dt]$ since after retirement, the individual does not provide labor supply.

The earnings profile the individual faces is as follows. Between age $t = 0$ and age $t = R$, the individual works and obtains some labor income determined by the after-tax wage rate $w_t(1 - \tau_t)$ and time supplied to the labor market. They also obtain returns from any investment made on the capital market at the risk-free rate of return. Between age $t = R$ and $t = T$, the individuals receives $\Phi(z)$ as social security benefit plus the assets returns. Let $A(t, z^t)$ be the level of asset held by the individual at period t and let the initial level of assets A_0 be equal to zero for simplicity. The level of assets at the end of each period is determined as the part of total income not consumed. The problem of the individual is to choose their consumption, labor supply, and retirement date given the evolution of assets and the feasibility constraint that the retirement date must be less than T. Hence the problem faced by the individual is:

$$\max_{\{c,h\}_{t=0,\dots,T}, R} = \mathrm{E}[\int_0^R (\frac{c(t, z^t)^{1+\phi}}{1+\phi} - m\frac{h(t, z^t)^{1+\theta}}{1+\theta})e^{-\rho t}dt + \int_R^T (\frac{c(t, z^t)^{1+\phi}}{1+\phi})e^{-\rho t}dt], \quad (1)$$

s.t.

$$A(\dot{t}, z^t) = rA(t, z^t) + w_t(1 - \tau_t)[1 - h(t, z^t)] - c(t, z^t), \forall t \leq R,$$
$$A(\dot{t}, z^t) = rA(t, z^t) + \Phi(z) - c(t, z^t), \forall t > R,$$
$$R \leq T,$$

where the dots indicate time-differentiation. In this economy, we have the possibility of full insurance. Hence, the set of equations relating to the evolution of assets over time can be written on the following single budget constraint:

$$\int_0^T \mathrm{E}[c(t, z^t)]e^{-rt}dt = \int_0^R w_t(1 - \tau_t)\mathrm{E}[h(t, z^t)]e^{-rt}dt + \int_R^T \mathrm{E}[\Phi(z)]e^{-rt}dt. \quad (2)$$

Let λ be the Lagrange multiplier of budget constraint. When the discount factor equals the risk free interest rate ($\rho = r$), the first order conditions are:

$$c(t, z^t) = \lambda^{1/\phi}, \forall t, \quad (3)$$

$$h(t, z^t) = \left[\frac{\lambda w_t(1 - \tau_t)}{m}\right]^{1/\phi}, \forall t, \quad (4)$$

$$w_R(1 - \tau_R)\mathrm{E}[h(R, z^R)] = w_R(1 - \tau_R)h(R, z^R) \geq \mathrm{E}[\Phi(z)]. \quad (5)$$

Equations (3) and (4) follow from the first order condition of consumption and labor supply, respectively. Notice that the right hand side of each of those equations does not depend on the random return. In fact, the right hand side of equation (3) is a constant, while the right hand side of equation (4), conditional on time, does not depend on the random return either. Equation (5) determines the retirement date. This equation indicates that when the expected value of social security benefits is as large as labor income, the individual is able to retire.[3] When the inequality slacks, the individual is unable to retire and works until $t = T$. The result for retirement is not surprising. In fact, the individual has a concave utility function on consumption and they would like to smooth consumption over time. Hence, large changes in income due to retirement are not desired, as they would produce large fluctuations in consumption.

An interesting property with respect to retirement date relates to the distribution function of the random asset. As the distribution function is normally distributed, we can write the expected value of benefits as $\mathrm{E}[\Phi(z)] = \Psi(\mu, \sigma^2)$, where $\psi_\mu > 0$ and $\psi_{\sigma^2} < 0$. In fact, the normal distribution function is completely characterized by its mean and variance and the expected value must be an increasing function of the mean while a decreasing function of the variance (see Varian 1992). Hence, the optimal condition that determines the retirement date can be written as:

$$w_R(1 - \tau_R)h(R, z^R) \geq \Psi(\mu, \sigma^2). \tag{5'}$$

Suppose the condition holds with equality, indicating an interior solution for R. An increase in μ must be related with lower labor supply and possibly with earlier retirement. In fact, the right hand side increases and the left hand side must adjust through labor supply and retirement date, as taxes and wages are exogenous to the individual problem. In the same way, an increase in the variance of the return must be associated with later retirement date by the same argument. The intuition for this result follows from the normality of leisure and the shape of the utility functions. When the mean of expected social security benefits increases, holding the variance constant, the individual is able to afford more leisure while when the variance increases, holding the mean constant, individuals prefer to accumulate more assets as a precaution for negative shocks on the social security rate of return.

We will discuss now the effect over the intensive margin labor supply decision, e.g., the number of hours supplied to the labor market. To characterize labor supply, it is useful to solve for the shadow price of wealth, λ. Using equations (3) and (4) plus the budget constraint, equation (2), we see that $\lambda = \lambda(w^*, \Phi^*)$,

$$\text{where, } w^* = \frac{\int_0^R [w_t(1 - \tau_t)]^{1+1/\theta} e^{-rt} dt}{m^{1/\theta} \int_0^T e^{-rt} dt}, \quad \Phi^* = \frac{\int_R^T \mathrm{E}[\Phi(z)] e^{-rt} dt}{\int_0^T e^{-rt} dt}, \text{ and } \lambda_{w^*}, \lambda_{\Phi^*} < 0.$$

[3] Notice that the first equality follows from equation (4), as the random return does not matter under full insurance.

This expression is quite intuitive. In fact, w^* and Φ^* are just nonlinear weighted average of labor income flows and expected social security benefits. Hence, the marginal utility of wealth (λ) is a decreasing function of those weighted average types of wealth. Basically, larger wealth is related with smaller marginal utility of wealth as in any lifecycle model.

Given this information, plus equations (4) and (5′), labor supply now can be easily determined. In fact labor supply will be given by:

$$\ln[h(t, z^t)] = -\frac{1}{\theta}\ln(m) + \frac{1}{\theta}\ln[\lambda(w^*, \mu, \sigma^2)] + \frac{1}{\theta}\ln[w_t(1-\tau_t)]. \quad (6)$$

As above, notice that the right hand side does not depend on the realized state of the risky assets; hence, the labor supply does not depend on it. This equation resembles the usual specification used in much literature (MaCurdy 1981). In fact, an increase in current after-tax wage rate, holding constant the shadow price, increases labor supply as this is a pure substitution effect while an increase in the shadow price, holding constant the after-tax wage rate, is a pure income effect and hence it decreases labor supply. The main difference with the literature is that the equation also shows that the properties of the distribution of the risky assets matters. In fact, a larger mean on the rate of return of the risky asset is associated with lower labor supply while larger variance of the return is associated with larger labor supply, on the intensive margin. The intuition is basically the same argument as in the case of retirement.

In summary, as it can be seen in equations (5′) and (6), a social security system that invests its funds in a risky asset may have important effects on retirement and labor supply due to the properties of the distribution of the risky assets. Larger returns on the risky assets are associated with income effects that produce earlier retirement and lower labor supplied to the labor market. However, larger variances of the risky assets are associated with later retirement and larger labor supplied to the labor market due to the precautionary motive.

Finally, it is easy to extend the model to a case where social security funds are not invested in risky assets. In that case, equations (5) and (6) become:

$$w_R(1 - \tau_R)h(R) \geq \Phi_R, \quad (5'')$$

$$\ln(h_t) = -\frac{1}{\theta}\ln(m) + \frac{1}{\theta}\ln[\lambda(w^*, \Phi^*)] + \frac{1}{\theta}\ln[w_t(1-\tau_t)], \quad (6')$$

where $\Phi^* = \frac{\int_R^T \Phi_t e^{-rt} dt}{\int_0^T e^{-rt} dt}$ and Φ_R is the social security benefit at R. Clearly in this case, only the increase in mean benefits matters, as there is no variance. The effect has the same sign, meaning that an increase in social security benefits is associated with earlier retirement and lower labor supply due to income effects.

This section emphasizes the second moment of the distribution of assets as a determinant of retirement and labor supply. This property holds due to the fact that we are using a normal distribution that is completely characterized by its two first moment conditions.

IV. THE EMPIRICAL STRATEGY

The empirical evidence focuses on the set of Chilean individuals aged 54 to 64 years old in 1998 enrolled in any social security system. We first estimate the probability of retirement using a switching regression model. We use a switching regression model because individuals may choose between two different statuses, enrollment in the IA social security system and enrollment in a PAYG system. Next, we estimate the labor supply function by correcting the self-selection decision of entering into the labor force, as in Heckman (1974). Those procedures are explained next.

A. *The Retirement Decision*

The estimation of the retirement decision function focuses on equations (5′) and (5″). Since the PAYG social security system presents less risk than the IA social security system, we relate equation (5″) to the PAYG social security system while we relate equation (5′) to the IA system. The difference is that retirement depends on the variance of the social security return in the case of the IA system while it does not in the PAYG system. This seems to be a fair assumption because, as explained in Section II, pensions in the PAYG social security system depend on a set of exogenous rules while they depend on volatile returns in the IA system.

The estimation will be based on a switching regression model as individuals could be enrolled in the PAYG or the IA system. The general specification of the econometric model will be as follows:

$$I_1^* = 1(PAYG) = 1(Z_1\gamma_1 > \varepsilon_1), \tag{7}$$

$$DR^{PG} = \beta_0^{PG} SSW + X\alpha + u, \quad \text{if } I_1^* = 1, \tag{8}$$

$$DR^{PS} = \beta_0^{PS} SSW + \beta_1^{PS} \mathrm{Var}(SSW) + X\alpha + u, \quad \text{if } I_1^* = 0, \tag{9}$$

where 1 (•) is an indicator function equal to one if the enclosed statement is true and zero otherwise while Z_1 are variables determining enrollment in the PAYG social security system. The error term ε_1 is an unobservable component that affects the decision process. The variable *DR* is an indicator function equal to one if the individual declares himself/herself as retired in the survey and zero otherwise. The variable *SSW* and Var(*SSW*) are the level and the variance of the return of the individual's portfolio in the IA system. The superscript *PG* and *PS* indicate PAYG and IA systems, respectively. Theory implies that β_0^{PG}, $\beta_0^{PS} \geq 0$ and $\beta_1^{PS} \leq 0$. The matrix X contains all other observable variables that may influence retirement, including demographic variables. Further, equation (5) or any of its alternative specifications indicate that current wage may be an important determinant of the retirement decision. Given that wages are not earned by everyone, additional variables such as education, age, and age squared are included to specify the behavior of underlying wage rates. Finally, u is a well-behaved error term.

The specification indicated by equations (7)–(9) can be combined in the following way:

$$DR = DR^{PS}(1 - I_1^*) + DR^{PG}(I_1^*), \text{ or} \tag{10}$$

$$DR = X\alpha + \beta_0^{PS}(SSW) + (\beta_0^{PG} - \beta_0^{PS})(I_1^* SSW) + \beta_1^{PS}[(1 - I_1^*)\text{Var}(SSW)] + u, \tag{11}$$

where $I_1^* SSW$ is a variable that includes the level of social security benefits if the individual is enrolled in the PAYG system and zero otherwise and $(1 - I_1^*)\text{Var}(SSW)$ is a variable that includes the variance of the level of benefits if the individual is enrolled in the IA system and zero otherwise. Variables *DR* and *SSW* represent the retirement indicator function and the present value of benefits in any social security system, respectively. Notice that the effect of an increase in IA social security wealth over retirement, holding constant the variance, is given by the coefficient on *SSW* while the effect of an increase in PAYG social security wealth is given by the sum of coefficients of *SSW* and $I_1^* SSW$. Finally, the effect of an increase in variance of social security benefits in the IA system is given by the coefficient of $(1 - I_1^*)\text{Var}(SSW)$.

To obtain consistent estimates, we require covariance between the right hand side variables and the error term being zero and thus, $\text{Cov}(SSW, u) = \text{Cov}(I_1^* SSW, u) = \text{Cov}[(1 - I_1^*)\text{Var}(SSW), u] = 0$. However, those conditions may possibly not hold, as individuals may choose between social security systems based on unobservable variables to the econometrician. Hence, direct estimation of equation (11) by least square might be biased.

To avoid the inconsistency problem, we use three exogenous instruments. This number of exogenous instrumental variables is sufficient to identify the parameters, as the number of variables presenting the self-selection problem is three—*SSW*, $I_1^* SSW$, and $(1 - I_1^*)\text{Var}(SSW)$. The first instrument will be an indicator function equal to one if the person is not self-employed and zero otherwise. We use this instrument because self-employed workers are allowed by the 1981 law to remain unenrolled in any social security system if they wish, but if they decide to enroll they must enroll in the IA system. Thus, this instrument measures obligatory enrollment in the social security system by excluding individuals that could remain not enrolled. The second instrumental variable is the set of individuals enrolled in the armed forces. The instrument will be a dummy variable equal to one if the individual works in the armed forces and zero otherwise. In fact, this set of individuals was required to remain enrolled in the PAYG system by the 1981 law and hence could not choose between systems. Finally, the third instrument is an indicator function equal to one if the individual was aged 43 years or less in 1981 and zero otherwise. We use this instrument because as explained in subsection II.B.3, the overall switching to the new system in 1981 was age dependant—older individuals were less likely to switch to the new system. An individual aged 43 years old in 1981 was aged 60 years old in 1998, the year the survey was carried out. Hence, the threshold represents the median age of the individuals in our sample, 54 to 64 years old.

The three instrumental variables are correlated with SSW, I_1^*SSW, and $(1 - I_1^*)\text{Var}(SSW)$, as they determine system selection. In addition, the instruments are exogenous since they depend on regulations of the 1981 law reform. Hence, those instruments should be uncorrelated with the error term of equation (11), as those individuals cannot react to the social security system as a response to unobservable variables. Some evidence of this fact is shown below.

B. *The Labor Supply Decision*

The second step on the labor supply estimation deals with the number of hours supplied to the labor market. In this estimation, we run first a probit model on labor force participation decisions. The probit resembles equation (11) but in this case, the set of individuals out of the labor force includes retired individuals, students, parents taking care of their children, etc. Hence, this group obviously has a larger size than the set of retired individuals. Using the probit estimates, we form a control function as in Heckman (1974), which we use in a second step in the estimation of the labor supply function. Finally, there is an additional problem: there could be endogenous selection between social security systems, as described in subsection IV.A.

To clarify the procedure, the main econometric system will be now described:

$$I_1^* = 1(PAYG) = 1(Z_1\gamma_1 > \varepsilon_1), \tag{7}$$

$$\ln(h^{PG}) = \alpha_0^{PG} SSW + \tilde{X}\tilde{\alpha} + \psi(\hat{c}_i) + e, \text{ if } I_1^* = 1, \tag{12}$$

$$\ln(h^{PS}) = \alpha_0^{PS} SSW + \alpha_1^{PS}\text{Var}(SSW) + \tilde{X}\tilde{\alpha} + \psi(\hat{c}_i) + e, \text{ if } I_1^* = 0, \tag{13}$$

where h indicates hours supplied to the labor market and $\psi(\hat{c}_i)$ is the fitted control function obtained from the estimation of the first step, i.e., the probit estimation. Equations (12) and (13) are the empirical counterpart of equations (6) and (6′) after controlling the selection decision of being in the labor force. Matrix X contains variables related to individual and job characteristics, plus after-tax labor income.

The set of equations can be combined in the following single equation:

$$\ln(h) = \alpha_0^{PS} SSW + (\alpha_0^{PG} - \alpha_0^{PS})(I_1^* SSW) + \alpha_1^{PS}[(1 - I_1^*)\mathrm{Var}(SSW)] + \tilde{X}\tilde{\alpha} + \lambda(-\hat{c}_i) + e. \tag{14}$$

As seen in equation (11), the effect of an increase in IA social security wealth over labor supply, holding constant the variance, is given by the coefficient on SSW, while the effect of an increase in PAYG social security wealth is given by the sum of coefficients of SSW and $I_1^* SSW$. The effect of an increase on the variance of social security benefits in the IA system is given by the coefficient of $(1 - I_1^*)\mathrm{Var}(SSW)$. The equation will also be estimated using instrumental variables due to the same argument stated above. The same set of instruments will be used.

V. THE DATA

This paper uses the 1998 Chilean survey of socioeconomic characteristics (CASEN) produced by the Chilean government during November and December of 1998. The survey was based on a random sample of 48,107 households[4] with a probabilistic error of 0.45%. There are 188,360 individuals in the sample. The survey includes information on schooling, health, housing, income, and employment plus demographic characteristics. We will describe next how we compute the main variables of the system, i.e., information concerning hours supplied to the labor market (if any), value of social security benefits, and the variance of the social security benefits in the IA system.

The employment section of the dataset provides information about labor status. The first question asks if the individual worked during the week before the survey was conducted. If the individual's answer was no, subsequent questions ask if they were absent temporarily from the job and if they had worked anytime during their lifetime. In that case, if the individual was not working and was not looking for a job, the survey asks about the reason why they were not searching for a job. Possible answers are sickness, taking care of children, student, not currently interested, or retired, among others. This question allows us to define an indicator function equal to one if the individual answers to be retired and zero otherwise. The intensive measure of labor supply, i.e., working hours the week before the survey was conducted, is directly measured by question 11 of the employment section.

The employment section of the survey also provides information about the social security system the individual is enrolled in.[5] The data show that among individuals aged 18 and older in 1981 (when social security was reformed), 41% are not affiliated

[4] The sample consists of 33,714 urban and 14,393 rural households.

[5] As social security taxes are paid as a fraction of labor income, the information of social security affiliation is directly linked to employment.

with any social security system, while 22% are enrolled in the PAYG system and 37% in the IA system. Those non-enrolled individuals are out of the labor force or self-employed workers.

We construct a variable containing the present value of the social security benefits (*SSW*) if the individuals were enrolled in the IA or the PAYG system as follows.

To estimate the present value of benefits of the PAYG system, we use data on retirement income (pensions) of retired individuals in the PAYG system. Similar to a Mincer equation, we estimate a reduced form equation, in which we run pensions as a function of age, age squared, schooling, and demographic variables—this is a way of capturing the effect of the exogenous regulations on pensions setting. Next, we use this equation to simulate the path of pensions on the PAYG system for all the individuals enrolled in the PAYG social security system—information known from the survey. To do so, we vary age, from 60 to 80 in the case of women and 65 to 80 in the case of men, to obtain the lifecycle retirement income profile for each individual in the PAYG system.[6] Finally, we construct the present value of benefits (measured at age 20) by discounting this income profile flow using a 5% interest rate.

To compute the level of the benefits in the IA system, we follow a different approach. Rather than estimating income profile upon retirement, we estimate labor income profile using the information on labor income available on individuals enrolled in the IA system. This information allows us to construct the present value of contribution, which is used to compute the present value of expected benefits in the IA system using the average rate of return of the private system. The way we proceed is as follows. We compute a Mincer-type equation for labor income as a function of age, age squared, and schooling (plus demographic variables). Using this equation and varying age from 20 to 65 in the case of men and 20 to 60 in the case of women, we obtain the estimated lifecycle income profile for each individual enrolled in the IA system. Since social security payroll tax rate has not varied since the 1981 reform, we compute contribution to the IA per year using the tax rate on the private system and the estimated lifecycle income profile. Using a 5% per year discount factor, we compute the present value of tax contribution. Finally, the expected present value of benefits can be computed using the average rental rate of the system.

There are also individuals that could have been enrolled in the PAYG system and switched to the IA system later. In this case, rather than using the rental rate of the funds, we construct as rental rate of return for contributions a weighted average between rate of return of the funds in the IA system and the 4% return paid by the

[6] Women should retire at 60 years and men at 65 years old by law. However, they could anticipate earlier retirement if they have a large amount of contributions in their retirement funds. See the 1981 law. Also, life expectancy was around 80 years old in 1998.

government for contributions realized in the PAYG system. The weights are defined as the fraction of time spent in each of the systems. For instance, if the individual is a woman and she spent 10 years of her life in the PAYG system, we define the weight for the rental rate paid by the government as 10/(60 – 20), where 60 is set as a prior retirement date and 20 is set as a prior entering date into the labor force. However, from the information of the survey, we do not know the moment the individual switched to the IA system. However, we know that the only set of possible individuals in this situation is the set of individuals in the labor force in 1981—individuals entering into the labor force after 1981 are not allowed to enroll in the PAYG system. Since almost 85% of individuals enrolled in PAYG system in 1981 switched to the IA system in 1981, we assume that any switching between systems was done in 1981. This assumption allows us to construct the average rental rate in this case.

TABLE III

SUMMARY STATISTICS

Variable	Number of Observations	Mean	Standard Deviation	Min.	Max.
1 (retired)	7,313	0.2056	0.4042	0	1
Hours worked	4,059	53.70	77.72	0	96
1 (married)	7,313	0.7168	0.4505	0	1
1 (widow)	7,313	0.1204	0.3255	0	1
Household size**	7,313	1.216	0.549	0	2.70
Social security benefits**	7,313	11.90	1.25	0	14.12
IA benefits**	3,253	12.44	0.66	10.75	14.12
Variance of benefits**	3,282	18.51	2.21	0	22.36
1 (govt. subsidy)	7,313	0.197	0.398	0	1
1 (female)	7,313	0.376	0.484	0	1
Education	7,254	8.16	4.23	0	19
1 (broken marriage)	7,313	0.067	0.251	0	1
1 (permanent work)	7,313	0.434	0.495	0	1
1 (temporary work)	7,313	0.088	0.284	0	1
1 (self-employed worker)	7,313	0.158	0.365	0	1
1 (armed forces worker)	7,313	0.001	0.03	0	1
1 (employee)	7,313	0.333	0.471	0	1
1 (family member working in family business)	7,313	0.004	0.066	0	1
Age in 1981	7,313	43.47	2.96	39	48
Labor income wealth (w^*)**	7,254	15.70	1.23	12.89	18.59

Source: See Table I.

Note: 1 (•) is an indicator function equal to one if the enclosed statement is true and zero otherwise. Also, "govt. subsidy" indicates a government subsidy to buy a house and ** indicates that the variables are in natural log.

To compute the variance of the benefits in the IA system, we calculate a standard deviation for the individuals' portfolios as follows. We know the average standard deviation of the investment in the IA system and we also know that if an individual contributes part of their life to the PAYG system and then switches to the IA system, the contributions to the old system will pay a 4% return with complete certainty. Hence, as described above, the standard deviation of the individual portfolio is set as a weighted average between the average standard deviation of the IA system and the zero-standard deviation of the PAYG system. Then, we use the present value of the contribution and the individual portfolio standard deviation to calculate the variance of the benefits in the IA system.

Finally, we must compute w^* to include it in the estimation of equation (14). This is a measure of the present value of labor income. To compute it, we use the estimated lifecycle income labor profile and we discount it at a 5% interest rate (we measure it at age 20). Table III provides summary statistics of these variables.

VI. RESULTS

A. *Instrumental Variables*

In this section, we first provide evidence concerning the appropriateness of the instrumental variables and later present and discuss the empirical results.

If individuals do not select between social security systems, we would not require the instrumental variable estimators as individuals would be randomly allocated between systems. However, there is some evidence indicating that this kind of selection might exist. Table IV tests for mean equality of different characteristics (demographic, labor income, subsidies, and geographic location) between social security systems. The first two columns relate to individuals enrolled in the PAYG system and the set of individuals enrolled in the IA system. The third column tests the equality between both, for the different characteristics in the table. The means reported in the columns corresponding to the PAYG system and the IA systems are statistically different for different variables considered, as shown in the third column. Thus, people in the two systems have different characteristics and individual selection between systems is highly probable.

We run a probit and a linear probability model between a dummy variable indicating PAYG enrollment and a set of observable variables. We use the set of individuals aged 35 years and older in 1998. Those individuals were 18 years and older in 1981 and could choose between social security programs. Both probability models are highly significant as is shown in Table V. This result indicates that people do choose among observable variables; therefore, it is highly probable that they select based on unobservable characteristics as well.

To solve our econometric problem, we require that the instrumental variables are

TABLE IV

Social Security Systems and Instrumental Variable Estimators by Characteristics (Individuals Aged 54 to 64 Years Old)

	PAYG (1)	IA (2)	*t*-test (3)	Armed Forces (4)	Non Armed Forces (5)	*t*-test (6)	Age ≤ 44 in 1981 (7)	Age > 44 in 1981 (8)	*t*-test (9)	Non Self-employed (10)	Self-employed (11)	*t*-test (12)
No. of Children	1.13	1.29	–5.46	1.22	1.25	0.08*	1.43	1.15	13.2	1.20	1.22	–0.4*
Size of household	3.8	3.97	–3.37	3.66	3.96	0.42*	4.13	3.86	7.7	3.73	3.91	–2.75
Married	0.66	0.77	–10.2	0.88	0.71	–1.1*	0.75	0.68	8.1	0.77	0.70	4.78
Widowed	0.14	0.08	8.8	0.00	0.12	1.1*	0.08	0.15	–12.2	0.07	0.12	–5.03
Female	0.44	0.27	15.2	0.11	0.52	2.4*	0.51	0.53	–1.8*	0.19	0.41	–13.8
Location	0.28	0.34	–5.7	0.44	0.27	–1.1*	0.27	0.27	0.09*	0.25	0.32	–4.29
Education	8.7	7.7	–10.3	12.0	7.4	–3.2	7.89	7.26	8.9	8.04	8.17	–1.0*
Hours worked	**46.6**	**48.2**	**–2.9**	**44.4**	**46.8**	**0.4***	**46.96**	**46.93**	**0.05***	**47.2**	**47.8**	**–0.9***
Labor income	189,269	279,249	–6.67	332,864	223,667	–0.6*	244,754	211,424	2.5*	293,889	222,606	4.71
Subsidy 1	1,162	1,382	–3.65	444	1,092	0.82*	1,197	1,036	4.03	713	1,368	–8.08
Subsidy 2	418	380	0.93*	0	542	0.80*	579	503	2.20*	465	389	1.4*
Subsidy 3	307	293	0.47*	222	305	0.19*	278	314	–1.70*	263	309	–1.1*
Subsidy 4	2,830	1,782	4.92	3,333	3,778	0.11*	2,774	4,427	–8.80	2,244	2,248	–0.5*

Source: See Table I.

Notes: 1. Location is a dummy variable equal to one if the individual lives in Santiago (the main city in Chile).

2. Subsidy 1 is a subsidy mainly related to minimum pensions for elderly. Subsidy 2 is governmental subsidy per child attending school. Subsidy 3 is an unemployment subsidy. Subsidy 4 is a subsidy for low-income families to pay for water supply services.

* indicates not statistically significant at the 1 percent level.

TABLE V

Probability Estimations of Enrollment in the PAYG System

	Linear Probability Dependent Variable 1 (PAYG)	Probit Dependent Variable 1 (PAYG)
Log of labor income	−0.007	−0.079
	(−2.40)	(−3.81)
1 (govt. housing subsidy)	−0.005	−0.039
	(−1.35)	(−1.31)
Age	−0.016	−0.015
	(−15.8)	(−2.21)
Age squared	0.0002	0.0006
	(22.7)	(9.09)
Years of education	−0.004	−0.023
	(−6.17)	(−5.71)
1 (female)	−0.003	−0.03
	(−0.92)	(−1.08)
1 (married)	−0.012	−0.12
	(−2.89)	(−3.18)
1 (widowed)	0.054	0.13
	(2.93)	(1.73)
1 (broken household)	−0.02	−0.15
	(−2.34)	(−2.55)
Log of household size	−0.003	0.03
	(−0.77)	(1.09)
1 (permanent work)	0.22	1.52
	(14.8)	(9.22)
1 (temporary work)	0.23	1.60
	(14.6)	(9.58)
1 (part time work)	0.24	1.59
	(12.2)	(9.11)
1 (illness)	0.009	0.02
	(1.94)	(0.83)
1 (in hospital in last 3 months)	0.01	0.09
	(3.27)	(3.06)
Pseudo R^2	0.3272	0.3513
Prob > χ^2 or F	0.0000	0.0000
No. of observations	49,886	49,886

Note: 1 (•) is an indicator function, one if true and zero otherwise. The estimation is among individuals 35 years and older. *t*-ratios are in parentheses. Job characteristics are omitted from the table.

uncorrelated with the error term, i.e., Cov(z, u) = 0 where z is our set of instrumental variables and u is the error term of equation (11) or equation (14). In fact, we should expect this result to hold as, for instance, the individuals in our control group in z were not allowed to choose between social security systems. It is not possible to determine the correlation between the unobservable variables and the instrumental variable, but even in that case, some useful tests may exist.

Note that a stronger condition will be zero covariance between the instrumental variables and the independent variable itself, namely, hours supplied to the labor market or retirement. The independent variable contains both observable and unobservable components and hence if there is no correlation between the independent variable and the instrumental variables, we have a good indicator that Cov(z, u) = 0 holds. A second type of condition that may indicate that Cov(z, u) = 0 holds is to check if the covariance between the instrumental variable and observable differences between households such as demographic variables, location, and income is zero. If this last covariance is not largely significant, we can be confident that demographic, location, or income shocks are not correlated with the instrumental variables and hence we have another good indicator that Cov(z, u) = 0 holds.

Table IV shows those tests for individuals aged 54 to 64 years old, the main group of analysis in this study. Columns (4)–(6) show the means and test its equality between individuals enrolled and not enrolled in the armed forces program while columns (7)–(9) test for mean equality for individuals aged less than 44 years old in 1981 and individuals aged more than 44 years old in 1981. Finally, columns (10)–(12) do the same analysis with self-employed and non–self-employed individuals. The row related to hours worked shows that in fact hours worked are statistically different between individuals enrolled in the PAYG and IA systems. However, hours worked are not statistically different for any of the different groups involved in the three instruments used. In fact, hours worked are statistically identical for armed force and non–armed force workers, for individuals aged 44 or less and individuals aged more than 44 years when the law passed, or for self-employed and non–self-employed individuals. Hence, Cov(z, y) = 0 cannot be rejected.

Similarly, Table IV tests whether the instruments are correlated with other observable shocks. Table IV tests for mean equality in demographic, location, and income variables (including subsidies). It is interesting to note that variables such as location, income, and subsidies present, in general, statistically equal means when the instrumental variables are used, but present statistically different means when we compare a private system versus the PAYG system. Hence, demographic characteristics, labor income shocks, subsidies shocks, and geographic shocks are uncorrelated with our instrumental variables.

B. *The Effects of the Social Security System on Retirement and Labor Supply*

Retirement decisions are estimated by means of equation (11). As retirement is a zero-one decision variable, we run a linear probability model and a probit model. To characterize the sensitivity of the results, we introduce additional variables on X and later we estimate the equation across individuals' groups (defined by age and income).

On the baseline specification, see Table VI. Matrix X includes schooling and demographic variables.[7] It also includes location variables indicating region and county of residency of the individual and government subsidies. The table includes results concerning OLS and 2SLS probability models of retirement. The signs of the parameters in the OLS case are different from the ones implied by theory. This is an indicator that choice between systems might bias our estimators. The results in the 2SLS case seem to correct the problem. They show that an increase of 1% in the level of social security wealth in the PAYG system produces an increase of 0.2% on the retirement probability on the linear probability model and a 0.6% on the probit model. The effect of the level of benefits in the IA system is a bit larger than in the PAYG system as shown by both models. In fact a 1% increase in social security wealth in the IA system should have a positive effect over retirement probability, ranging from 0.6% on the linear probability model to a 1.8% on the probit model. The effects of a 1% increase in the variance of the benefits in the IA system are associated with a 0.6% decrease in the probability of retirement in the linear probability model and with almost a 1% decrease in the probability of retirement in the probit model. Columns (4)–(6) and (7)–(9) of the table present the results when matrix X additionally includes variables relating to health status and age. The results in both cases are similar. Table VII presents the results for different groups. The results do not differ significantly in general.

In summary, estimating directly equation (11) seems to bias the estimators while the instrumental variable approach is very consistent, as changing the specification of the model and the groups used on the estimating sample does not significantly modify our point estimates.

The effects of social security system over hours worked are shown in Table VIII. Column (1) shows the results for the baseline case. This case includes as independent variables the same variables included on the retirement decision plus the lifetime labor income, w^*, the control function, the natural log of labor income, and job characteristics.[8] Column (2) shows the estimations among individuals on the lowest 60th percentile of the income distribution while column (3) shows the estimation for the richest 40th percentile. Finally, Columns (4) and (5) show the estimations for individuals aged 54 to 60 years old and individuals aged 61 to 64 years old.

Column (1) shows that larger lifetime labor income would depress current labor supply. This is an income effect holding constant current wages. In addition, larger social security wealth should depress labor supply on both systems and larger variance of benefits in the IA system should increase labor supply. Those results are in

[7] Dummy variables for females, for married individuals, for widowed individuals, for broken households, and for the size of the household.

[8] Basically, we include dummy variables for permanent, temporary and part time jobs.

TABLE VI

RETIREMENT DECISIONS (Individuals Aged 54 to 64 Years Old)

	LS	IV		LS	IV		LS	IV	
	Linear Probability (1)	Linear Probability (2)	Probit (3)	Linear Probability (4)	Linear Probability (5)	Probit (6)	Linear Probability (7)	Linear Probability (8)	Probit (9)
SSW	0.004	0.19*	0.57*	0.004	0.19*	0.57*	−0.006	0.21*	0.54*
	(0.12)	(24.9)	(163.7)	(0.12)	(24.92)	(166.59)	(−0.18)	(25.06)	(11.06)
I_1^*SSW	−0.26*	0.38*	1.23*	−0.26*	0.37*	1.23*	−0.24*	0.42*	1.18*
	(−13.1)	(12.1)	(292.1)	(−13.07)	(12.1)	(294.5)	(−12.16)	(14.56)	(10.83)
$\text{Var}[(1-I_1^*)SSW]$	−0.02	−0.6*	−0.97*	−0.002	−0.35*	−0.96*	−0.0014	−0.34*	−0.91*
	(−1.82)	(−12.3)	(−430)	(1.82)	(12.29)	(−433.5)	(−0.86)	(−12.9)	(−10.8)
1 (govt. subsidy)	−0.05*	−0.04*	−0.01*	−0.057*	−0.043*	−0.01*	−0.045	−0.04	−0.01*
	(−3.8)	(−2.79)	(−2.6)	(−3.84)	(−2.89)	(−2.70)	(−3.09)	(−2.83)	(−2.72)
1 (female)	−0.05*	−0.02	−0.006	−0.05*	−0.02	−0.007	−0.046	−0.02	−0.006
	(−3.6)	(−1.35)	(−1.55)	(−3.55)	(−1.52)	(−1.71)	(−2.98)	(−1.49)	(−1.57)
Education	0.02	−0.0002	−0.000	0.002	−0.000	−0.000	0.0048	0.0004	0.000
	(0.62)	(−0.18)	(−0.28)	(0.62)	(−0.04)	(−0.12)	(1.12)	(0.26)	(0.12)
Other Demographics	YES	YES	YES	YES	YES	YES	YES	YES	YES
Location var.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Health var.	NO	NO	NO	YES	YES	YES	YES	YES	YES
Age	—	—	—	—	—	—	YES	YES	YES
R^2	0.1582	0.1432	0.1622	0.1585	0.1438	0.1637	0.1860	0.1537	0.1756
No. of observations	8,035	8,032	8,032	8,035	8,032	8,032	8,035	8,032	8,032

Note: The variables *SSW*, (I_1^*SSW), and $\text{Var}[(1-I_1^*)SSW]$ are measured in natural log. When $I_1 = 1$, the variable (I_1^*SSW) is set equal to zero. Similarly, when $I_1 = 0$, the variable $\text{Var}[(1-I_1^*)SSW]$ is set equal to zero. In the notation, 1 (•) is an indicator function equal to one if the enclosed statement is true and zero otherwise. Also "govt. subsidy" indicates a government subsidy to buy a house.

* represents statistical significance at the 1 percent level. *t*-tests are in parentheses.

TABLE VII

RETIREMENT DECISIONS

A. Retirement Decisions by Income Group (Individuals Aged 54 to 64 Years Old)

	LS	IV		LS	IV	
	Linear Probability Lowest 60th Percentile	Linear Probability Lowest 60th Percentile	Probit Lowest 60th Percentile	Linear Probability 60–100th Percentile	Linear Probability 60–100th Percentile	Probit 60–100th Percentile
SSW	−0.39	0.19*	0.99*	0.027	0.22*	0.23*
	(−0.86)	(17.51)	(9.07)	(0.52)	(17.11)	(8.18)
$I_1^* SSW$	−0.17*	0.41*	2.08*	−0.30*	0.43*	0.51*
	(−8.36)	(10.45)	(8.59)	(−9.30)	(9.63)	(8.03)
$\text{Var}[(1 - I_1^*)SSW]$	−0.003	−0.32*	−1.60*	−0.0005	−0.36*	−0.39*
	(−1.56)	(−9.19)	(−8.55)	(−0.19)	(−8.66)	(−8.09)
1 (govt. subsidy)	−0.024	−0.022	−0.01	−0.061*	−0.06*	−0.006*
	(−1.32)	(−1.17)	(−0.97)	(−2.65)	(−2.64)	(−2.61)
1 (female)	−0.068	−0.038	−0.022	−0.03	−0.015	−0.001
	(−3.56)	(−1.99)	(−2.20)	(−1.38)	(−0.71)	(−0.76)
Education	0.005	−0.001	−0.0007	0.003	−0.0008	−0.0001
	(0.94)	(−0.51)	(−0.53)	(0.47)	(−0.3)	(−0.40)
Other demographics	YES	YES	YES	YES	YES	YES
Location var.	YES	YES	YES	YES	YES	YES
Health var.	YES	YES	YES	YES	YES	YES
Age	YES	YES	YES	YES	YES	YES
R^2	0.1766	0.1405	0.1567	0.2123	0.177	0.2055
No. of observations	4,623	4,623	4,623	3,412	3,409	3,409

B. Retirement Decisions (Individuals Aged 54 to 60 Years Old and Individuals Aged 61 to 64 Years Old)

	LS	IV		LS	IV	
	Linear Probability 54–60 Years	Linear Probability 54–60 Years	Probit 54–60 Years	Linear Probability 61–64 Years	Linear Probability 61–64 Years	Probit 61–64 Years
SSW	0.007	0.21*	0.65*	−0.025	0.21*	0.72*
	(0.19)	(11.69)	(2.58)	(−0.52)	(15.98)	(6.54)
$I_1^* SSW$	−0.21*	0.41*	1.39**	−0.36*	0.21*	0.26
	(−9.28)	(7.30)	(2.5)	(−12.18)	(3.76)	(0.18)
$\text{Var}\ [(1 - I_1^*)SSW]$	−0.0007	−0.32*	−1.07**	0.0004	−0.16*	−0.15
	(−0.38)	(−5.99)	(−2.5)	(0.20)	(−3.45)	(−0.13)
1 (govt. subsidy)	−0.045*	−0.040	−0.014**	−0.05	−0.046	−0.029
	(−2.84)	(−2.52)	(−2.4)	(−2.12)	(−1.87)	(−1.90)
1 (female)	−0.068*	−0.046*	−0.017	−0.029	0.004	0.002
	(−3.86)	(−2.67)	(−2.7)	(−1.23)	(0.17)	(0.16)
Education	0.0007	−0.001	−0.0006	0.008	0.002	0.002
	(0.15)	(−0.93)	(−0.98)	(1.44)	(1.23)	(1.21)
Other demographics	YES	YES	YES	YES	YES	YES
Location var.	YES	YES	YES	YES	YES	YES
Health var.	YES	YES	YES	YES	YES	YES
Age	YES	YES	YES	YES	YES	YES

TABLE VII (Continued)

	LS	IV		LS	IV	
	Linear Probability 54–60 Years	Linear Probability 54–60 Years	Probit 54–60 Years	Linear Probability 61–64 Years	Linear Probability 61–64 Years	Probit 61–64 Years
R^2	0.1579	0.1039	0.1450	0.1646	0.1242	0.1353
No. of observations	5,102	5,101	5,101	4,323	4,320	4,320

Note: The variables *SSW*, (I_1^*SSW), and Var[$(1 - I_1^*)SSW$] are measured in natural log. When I_1 = 1, the variable (I_1^*SSW) is set equal to zero. Similarly, when $I_1 = 0$, the variable Var[$(1 - I_1^*)$ *SSW*] is set equal to zero. In the notation, 1 (•) is an indicator function equal to one if the enclosed statement is true and zero otherwise. Also, "govt. subsidy" indicates a government subsidy to buy a house.
* and ** represent statistical significance at the 1 percent and 5 percent level, respectively. *t*-tests are in parentheses.

TABLE VIII

LABOR SUPPLY (Individuals Aged 54 to 64 Years Old)

	IV				
	Ln (Hours Worked) (1)	Ln (Hours Worked) Lowest 60th Percentile (2)	Ln (Hours Worked) 60–100th Percentile (3)	Ln (Hours Worked) 54–59 Years (4)	Ln (Hours Worked) 60–64 Years (5)
SSW	–0.11**	0.11	–0.18*	–0.038	–0.20**
	(–1.97)	(0.94)	(–2.86)	(–0.43)	(–2.08)
I_1^*SSW	–0.19	0.02	–0.26	–0.064	–0.089
	(–1.45)	(0.08)	(–1.75)	(–0.29)	(–0.57)
Var[$(1 - I_1^*)SSW$]	0.17	0.018	0.21	0.093	0.072
	(1.57)	(0.09)	(1.71)	(0.51)	(0.57)
Ln(w^*)	–0.014	–0.008	–0.013	–0.01	–0.029**
	(–1.53)	(–0.64)	(–1.02)	(–1.02)	(–1.93)
Ln(labor income)	0.072*	0.20*	0.05*	0.063*	0.08*
	(5.32)	(3.92)	(2.93)	(4.66)	(3.42)
Control function	–1.09*	–0.41	–1.13*	–0.71**	–1.55**
	(–3.07)	(–0.67)	(–2.72)	(–2.03)	(–2.36)
Demographics	YES	YES	YES	YES	YES
Location var.	YES	YES	YES	YES	YES
Health var.	YES	YES	YES	YES	YES
Age	YES	YES	YES	YES	YES
Job var.	YES	YES	YES	YES	YES
R^2	0.0940	0.1402	0.1141	0.0876	0.1225
No. of observations	4,447	2,259	2,188	3,174	2,010

Note: The variables *SSW*, (I_1^*SSW), and Var[$(1 - I_1^*)SSW$] are measured in natural log. When I_1 = 1, the variable (I_1^*SSW) is set equal to zero. Similarly, when $I_1 = 0$, the variable Var[$(1 - I_1^*)SSW$] is set equal to zero. In the notation, 1(•) is an indicator function equals to one if the enclosed statement is true and zero otherwise. Also, "govt. subsidy" indicates a government subsidy to buy a house.
* and ** represent statistical significance at the 1 percent and 5 percent level, respectively. *t*-tests are in parentheses.

line with theory; however, the coefficient of I_1^*SSW and $(1 - I_1^*)\text{Var}(SSW)$ are not significant. Since the coefficient of SSW is significant while the one of I_1^*SSW is not, we may conclude that the effect of an increase of the social security wealth is the same in both systems. The point estimate shows that an increase of 1% in social security wealth should be associated with a 0.1% decrease in hours of labor supplied to the market. The control function is significant indicating that choice in the decision of entering the labor force arises and labor income has a positive and significant effect over hours supplied to the labor market, as expected.

However, estimates obtained for individuals in the lowest 60th percentile of the income distribution seem to indicate that those individuals are not affected by social security and their point estimate elasticity with respect to current labor income, a substitution effect, is larger than for the richest individuals. This latter group of individuals seems to react to changes in the level of social security benefits. The point estimates for the variance seems to be more significant, but nevertheless we cannot reject the null hypothesis that the coefficient is zero at 5%. Hence, social security seems to affect the extensive margin rather than the intensive margin decision.

VII. SUMMARY AND POLICY IMPLICATIONS

This paper deals with the effect of the social security system on labor supply and retirement decisions in the case of Chile. This case allows us to investigate the effects of the PAYG and the IA systems. A stylized theoretical model provided in the paper indicates that larger social security wealth should depress labor supply and induce earlier retirement while larger variance of those benefits should increase labor supply and induce later retirement. The paper, under different specifications and for a different group of individuals aged between 54 and 64 years old, shows that those predictions are, in general, empirically corroborated. Thus, two phenomena may explain part of the decrease in the retirement rate in Chile during the 1990s: (1) a larger percentage of individuals enrolled in the IA system and (2) larger variance of social security benefits which provides incentives to retire later due to the precautionary motive.

REFERENCES

Arellano, Jose Pablo. 1985. *Politicas sociales y desarrollo: Chile, 1924–1984*. Santiago: Corporación de Estudios para Latinoamérica (CIEPLAN).

Bustamante, Julio; Augusto Mouchard; and Erwin Schulthess. 1996. *Reforma a los sistemas de pensiones: Argentina, Chile y Peru*. Santiago: Superintendencia de AFP.

Deaton, Angus. 1992. *Understanding Consumption*. New York: Oxford University Press.

Diaz, José; Rolf Luders; and Gert Wagner. Forthcoming. *La República en Cifras: Chile, 1810–2000*. Santiago: Central Bank of Chile.

Gruber, Jonathan, and David Wise. 1997. “Social Security Programs and Retirement around the World.” NBER Working Paper no. 6134. Cambridge, Mass.: National Bureau of Economic Research.

Hachette, D. 1998. “Ahorro privado en Chile.” *Cuadernos de economía* 35: 3–48.

Heckman, James. 1974. “Shadow Prices, Market Wages, and Labor Supply.” *Econometrica* 42, no. 4: 679–94.

Kotlikoff, Laurence J. 1996. “Simulating the Privatization of Social Security in General Equilibrium.” NBER Working Paper no. 5776. Cambridge, Mass.: National Bureau of Economic Research.

Lee, Lung-Fei. 1978. “Unionism and Wage Rates: A Simultaneous Equations Model with Qualitative and Limited Dependent Variables.” *International Economic Review* 19, no. 2: 415–33.

MaCurdy, Thomas E. 1981. “An Empirical Model of Labor Supply in a Life-Cycle Setting.” *Journal of Political Economy* 89, no. 6: 1059–85.

Maddala, G. S. 1983. *Limited-Dependent and Qualitative Variables in Econometrics*. Econometric Society Monographs no. 3. Cambridge: Cambridge University Press.

Schmidt-Hebbel, Klaus. 1998. “Does Pension Reform Really Spur Productivity, Saving, and Growth?” Central Bank of Chile Working Paper no. 33. Santiago: Central Bank of Chile.

Varian, Hal R. 1992. *Microeconomic Analysis*. 3rd ed. New York: W.W. Norton.