Optimal enrolment in a pension system and informal family arrangements

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Abstract

This paper uses a life-cycle approach in combination with means of old-age family support to better understand the individual decision to enrol in a pension system in the context of a developing country. We compute the utility based measure IEV (Income Equivalent Variation) in order to account for life-cycle considerations. Our calibration and econometric results with Peruvian data allow us to suggest that the life-cycle approach and old-age family support are complementary to understand pension enrolment. Policies that positively affect the IEV (e.g. higher pension fund return, less administrative fees, more generous pension rules, etc.) raise the probability of enrolment whilst old-age family support reduces this probability.

JEL classification: H55, J14, G22, G23

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1. Introduction

Some developing countries have reformed their pension systems in order to provide social protection to the elderly. For instance, during the last 30 years a number of Latin American countries have converted their pension systems into individual account based systems characterized by strong private sector participation in the management of pension funds. Although some benefits of the pension reform, such as the development of the capital market, are generally acknowledged (Arenas de Mesa and Mesa Lago, 2006), the fraction of population effectively covered by the pension system has hardly increased (Rofman and Lucchetti, 2006). This means that a significant number of individuals will not have a pension to cover their expenses in old age. Nevertheless, in those countries family support from children or extended family can be viewed as a way to cope with the loss of income and health deterioration in old age[1]. Therefore, the existence of informal family arrangements may be one of the reasons behind the low levels of enrolment in the pension system apart from those frequently cited in the literature, i.e. poverty and large informal sector.

However, this is not the whole story. It is still possible that, given the parameters of the pension system, the individual chooses optimally not to enrol based solely on his preferences for risk and inter-temporal consumption. A life-cycle model approach may contribute to understanding an individual's decision to enrol in a pension scheme. For the purpose of this study, it can be assumed that this decision amounts to the decision to acquire an annuity[2]. If the only source of uncertainty is the date of death, there are no bequest motives, markets are complete and annuities are actuarially fair, then the basic life-cycle model (Yaari, 1965) predicts full annuitization. Thus, the individual must purchase an annuity to smooth consumption over time and overcome unexpected length of lifespan. However, markets are far from complete in developing countries, and actuarially fair pensions are inexistent due to high administrative fees and mortality tables with underestimated mortality introduced with the pension reform (Palacios and Rofman, 2001). Thus, we may expect low levels of enrolment in the pension system regardless of

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[1] There is a large amount of literature that stresses the importance of family and particularly child support to the parents in old age. For example, see Hoddinott (1992), Cox et al (1998), Jellal (2002), Cox and Fafchamps (2008) and Cameron and Cobb-Clark (2008).

[2] Indeed, in the new Latin American private pension systems the individual accrues his contributions and returns in an own account until retirement age; and at this age he has to purchase an annuity by using all the accumulated resources.

the existence of family arrangements. Overall, it is difficult to establish a precise relationship between low enrolment and family arrangements.

If we assume that informal family arrangements are substitutes for enrolment in the pension system, then, to what extent is it appropriate to create a pension system? Chetty and Looney (2006) show that the introduction of social insurance in developing countries may result in welfare gain if households are high risk averse. In developing economies, consumption may fluctuate only slightly as households are able to smooth consumption during income shocks by using family arrangements; hence, the introduction of social insurance might be redundant. However, the authors point out that households firmly want to smooth consumption during shocks due to their high risk aversion, even at the expense of important welfare costs (e.g. children taken out of school). In such a case, social insurance in developing economies might contain welfare losses and also enhance health and education conditions (Morduch, 1995). In the same vein, Davidoff et al (2005) argue in favour of compulsory annuitization in the context of incomplete annuity markets, which is also applicable to developing countries. They indicate that low annuity demand might be caused by individual behavioural considerations, and therefore compulsory annuitization could increase welfare.

Accordingly, the role of family arrangements on the enrolment in pension systems must be analysed jointly with the characteristics of the pension reform and its effects on the optimal decision to enrol. For instance, Kotlikoff and Spivak (1981) make use of indirect utility functions to calculate the increment on the initial wealth need to leave an individual who has not acquired an annuity as well off he would be with no additional wealth but with a purchased annuity. These authors find that the family can partially substitute a fair annuities market by pooling risks. Similarly, Brown (2001) analyses how the differences in preferences for risk, mortality, health and marital status of individuals affect the decision to annuitize. However, whilst Kotlikoff and Spivak (1981) use only calibration, Brown (2001) combines survey data information with parameters elicited from the same dataset. The approach used by Brown (2001) is more thorough and specific for a given reality but it is quite demanding on information; particularly it requires perceptions of risk and subjective mortality by the individuals, apart from the common set of demographic variables. However, those studies do not explore the influence of informal family arrangements on the demand for annuities. Then, in addition to all the mentioned variables, we also should have information or good *proxies* on informal family arrangements. Interestingly, the Social Risk Management Survey (PRIESO), a survey and large-scale field experiment conducted by the World Bank in Peru in 2002, fulfils these data requisites. Thus, we examine the case of Peru, a country that reformed its pension system in the early 90's. In addition, the extended family and traditional means of old-age support are prominent in Peru, which offer the opportunity to study the interplay between pension enrolment and family arrangements[3].

Given that the Peruvian pension system is formed by a private (SPP) and a public (SNP) pension system, the individual must choose one of them to enrol in or remain out of pension coverage. We can model this decision as a choice in two steps: firstly, the individual decides to enrol in the pension system or not; and secondly, he chooses the SPP or SNP given he decided to enrol. In order to analyse the rationality of individuals, we can calculate the additional percentage of increase or decrease in income required to make the individual indifferent between enrolling and not enrolling. For instance, if the individual is not enrolled in the pension system, we calculate the percentage of income required to leave this individual as well off he would be enrolled but without this income increase. Analogously, we also obtain the same measure when the individual is enrolled in the pension system. We call this measure the income equivalent variation (IEV). The IEV allows us to observe how the person values the option of enrolling with respect to the option of not-enrolling, and indirectly we can also know how he values relatively the SPP and SNP. For example, if the individual optimally chooses not to enrol, we should expect that he exhibits a negative IEV.

Once IEV is computed for each individual in the PRIESO sample, we compare it with the actual status of the individual enrolment and analyse the consistency of the choice. We expect some individual choices appear as not optimal due to aspects that we are unable to control purely with the IEV. To overcome this, we propose to run a probit equation with the dependent variable indicating if the person is enrolled in the pension system or not. In that equation, we include as regressors the IEV computed for each individual, demographic variables and *proxies* for family arrangements. We calibrate the IEV by using some institutional parameters such as contribution rate, administrative fees, interest rate, mortality and benefit rules. Furthermore, we also use a mortality table elicited from the

[3] Previous studies with Peruvian data show that individuals expecting receive pensions are less interested to enter into old-age support arrangements such as monetary and time transfers within the household (Cox et al, 1998). Similarly, Li and Olivera (2009) find evidence for a relation of substitution between informal family arrangements and enrolment in the Peruvian pension system.

answers of individuals about their subjective mortality as an alternative to the official mortality table.

The novelty of this analysis is that it allows us to consider institutional aspects of the pension reform that can be changed discretionary by the authority (e.g. mortality tables, contribution and interest rates, fees, etc.) and individual characteristics such as preferences for risk, expectations, subjective mortality and family arrangements. Thus, apart from understanding individual behaviour on social security enrolment in the context of a developing country, we can derive some policy implications. The rest of the paper is organized as follows. Section 2 presents the background of the Peruvian pension system. The theoretical framework and our calibration strategy model are set out in section 3. Section 4 deals with the data and elicitation of parameters. Section 5 shows the empirical results. And finally, section 6 concludes.

2. Background: the Peruvian pension system

One of the most notorious economic reforms undertaken in a number of Latin American countries during 1990's is the conversion of the PAYG pension systems into individual account pension systems. Though the emphasis of the reform varies from country to country, the essential characteristics are observable in all the experiences: private fund managing, individual accounts of capitalization, annuities provided by insurance firms, etc. Peru did not escape from this reform wave. Since June 1993, the Peruvian pension system is formed by two competing systems, the National Pension System (SNP) and the Private Pension System (SPP). Although the SNP and SPP are the main pension systems, there are schemes exclusively designed for some occupational groups. There is a pension system only for the army and police forces, for fishermen, and for some public servants that currently do not allow more enrolments (Law 20530). Different from other countries that completely or partially replaced their old PAYG systems, Peru launched the SPP as a fully fund pension system based on individual capitalization without dismantle the SNP. Under the most popular classification for pension reforms in Latin America[4], the Peruvian

[4] According to Arenas de Mesa and Mesa Lago (2006), the types of pension reform are i) Substitutive, where the PAYG system is fully replaced by a fully fund system (Bolivia, Chile, Dominican Republic, El Salvador and Mexico), ii) Mixed, where the PAYG and the fully fund system are complementary, with both providing a share of the pension to the insured (Argentina, Costa Rica and Uruguay), and iii) Parallel (Colombia and Peru).

reform is categorized as a parallel reform type since it allows the coexistence and "competition" between the SPP and SNP.

The SNP is a defined benefit (DB) system type that offer a pension calculated with known pension rules. Among these rules are a minimum period of 20 years of contribution, minimum and maximum values for the pension, and a replacement ratio that depends on the number of contributions and the birth cohort of the pensioner. As a DB pension system, the sustainability of the SNP relies heavily on the relation between contributors and pensioners and the typical parameters of this type of pension system, i.e. contribution rate, retirement age, replacement ratio, etc.

In contrast, the SPP is a self-financed system due to it is based on individual capitalization. Each insured have to choose one of the Pension Fund Administrators (AFP) and open an own and non-transferable individual account where his contributions and the returns earned in the pension fund are accumulated through his labour life. Those firms are in charge of investing the contributions made by the insured and managing the pension funds. At the retirement age, the insured is legally obligated to buy an annuity from an insurance company with the total balance of his individual account or to acquire monthly programmed withdrawals managed by the AFP. Furthermore, the insured may also choose a combination of an annuity with some years of programmed withdrawals.

In both systems the retirement age is 65 for women and men, though early retirement is possible under certain requisites. Likewise, the contribution rate is a fixed percentage of the total monthly salary. Currently this rate is 13% and 10% for the SNP and SPP respectively, thought the SPP's contribution rate was 8% at the time of the application of PRIESO. The AFP charges an administrative fee and collects the insurance premium as a percentage of the insured's monthly salary. The former concept is the payment for managing and investing the pension funds, collecting contributions and other administrative responsibilities, whilst the latter is given to an insurance firm that covers the risks of disability and death. The administrative fee and insurance premium were 2.28% and 1.27% in average, respectively.

The workers have to choose only one of these systems to contribute and receive a pension. Within the SPP, an insured can shift from one AFP to another if the legal requisites are fulfilled. Furthermore, those workers who are enrolled in the SNP can shift to the SPP but the contrary is not possible. The intention behind this regulation is related to the financial deficit of the SNP and the interest of the pension reform designers to strengthen the SPP. This system is intrinsically less exposed to the demographic risk and with not future fiscal responsibilities at all. In order to compensate the insured that shifts from the SNP to the SPP, the State entitles him a 'recognition bond' for the contributions made to the SNP. Some legal requirements have to be fulfilled to obtain this bond, which can be 1992 or 1996 type depending on the year used to account backwards for past contributions. The value of the bond is actualized by the prices index up to the date of retirement, and only at this date the bond is paid and deposited in the individual pension account.

As a typical DB system, the SNP offers a minimum pension to all insured that fulfil the corresponding requisites. In contrast, the SPP offers a limited minimum pension guarantee that is only reachable for individuals born before 1945, with earnings at the level of the minimum legal income or higher and contributions for at least 20 years to any pension system[5]. In general, the SNP may be preferred by low income earners who might obtain at least a minimum pension, whilst the SPP may be favoured by medium and high income workers. Additionally, the timing of the reform also has an important role. Those insured that were close to fulfil the requirements to retire and obtain a pension in the SNP (mainly the older ones) might have chosen keeping enrolled there because the SPP did not offer them a certain pension and/or a fair 'recognition bond'. Therefore, the younger insured were more attracted to shift from the SNP to the SPP. In addition, a young individual might prefer to enrol in the SPP because he will capitalize his pension balance more and hence may obtain a larger benefit.

3. Theoretical framework and calibration

We use a life-cycle approach to model the decision to enrol or not in any pension system by adapting the models presented in Kotlikoff and Spivak (1981) and Brown (2001) to include the characteristics of the Peruvian pension system. We consider the decision of enrolling as one of annuitize. If the exact age of death is unknown for the individual, then he could be interested to enrol in one of the pension systems in order to obtain enough streams of income (in the form of a pension) from his retirement date until his death. We also assume that death date is the only source of uncertainty and that there are no bequests; therefore, the individual wishes to consume all his resources until his death. For simplicity, we assume that the individual earns a constant stream of income Y over his

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[5] This regulation was valid between December 2001 and March 2007. And then, the birth date requisite was abolished but the minimum pension was restricted to persons that shifted from the SNP to the SPP.

labour span until retirement. At age x, the individual must maximise his inter-temporal expected utility:

$$E(U)=\sum_{t=0}^{D-x} {}_{x}p_{t}U(C_{t})\alpha^{t} \tag{1}$$

D is the maximum survival age. C_t is the consumption in time t, δ is the individual subjective rate of time preference, with α=1/(1+δ), and ${}_{x}p_{t}$ is the probability of survival from age x to age x+t. If the individual does not enrol in a pension system, the optimal consumption plan is obtained from the maximization of equation 1 subject to the next restriction:

$$\sum_{t=0}^{D-x}C_{t}Z^{-t}=\sum_{t=0}^{R-x-1}YZ^{-t} \tag{2}$$

R is the age of retirement and r is the discounting interest rate, with Z=(1+r). The discounted consumption plan in the left-hand side of 2 must be financed with all discounted resources earned between ages x and R.

If the individual intends to enrol in the SPP, he should maximise equation 1 subject to:

$$\sum_{t=0}^{D-x} {}_{x}p_{t}C_{t}Z^{-t}=\sum_{t=0}^{R-x-1}Y(1-a-c_{spp})Z^{-t}+\sum_{t=R-x}^{D-x}P_{spp}Z^{-t} \tag{3}$$

$$P_{spp}=\frac{CIC_{R}}{CRU_{R}}=\frac{\sum_{t=0}^{R-x-1}c_{spp}Y(1+\tilde{r})^{t}}{CRU_{R}} \quad \text{and} \quad CRU_{R}=\sum_{j=0}^{D-R}\frac{{}_{R}p_{j}}{(1+\hat{r})^{j}} \tag{3'}$$

Where a is the administrative fee (plus the insurance premium) paid to the pension fund manager, c_{spp} is the contribution rate applied to the salary and P_{spp} is the retirement pension. Equation 3 indicates that all resources received during labour life and retirement must finance the consumption plan C_t. Differently from the case of not-enrolling, this consumption plan incorporates the basic characteristic of an annuity: the probability of survival is included in order to smooth consumption through labour life and retirement. This means that, given the probabilities of survival, the individual is able to consume all his wealth through his life-span. The computation of the pension follows the formula indicated in equation 3′. During labour life the individual accumulates resources in his pension fund account which earns an interest rate of $\tilde{r}$. The individual must compulsorily acquire an annuity from an insurance company with the total pension fund balance put in front at the retirement age (CIC_R). CRU_R is the annuity price. $\hat{r}$ is the interest rate offered by the insurance firm to the individual; the larger this interest rate, the lower the annuity price, the larger the pension. The price of the annuity for an individual who has spouse must be calculated in such a way that it allows the widow receives a survival pension after the death of the pensioner. In the next formula, ψ is the percentage of the husband's pension that the widow will receive, ${}_y q_i$ is the probability of survival from age *y* to age *y*+*i* for the widow.

$$CRU_R = \sum_{j=0}^{D-R} \frac{{}_R p_j}{(1+\hat{r})^j} + \psi \sum_{i=0}^{D-y} \frac{{}_y q_i}{(1+\hat{r})^i} (1 - {}_R p_i) \qquad (3'')$$

Instead of enrolling in the SPP, the individual may choose the SNP, so that he maximises equation 1 subject to the next restriction:

$$\sum_{t=0}^{D-x} {}_x p_t C_t Z^{-t} = \sum_{t=0}^{R-x-1} Y(1-c_{snp}) Z^{-t} + \sum_{t=R-x}^{D-x} P_{snp} Z^{-t} \qquad (4)$$

$$P_{snp} = Min\{Max(\beta Y; P_{\min}); P_{\max}\} \qquad (4')$$

The individual must contribute the unique share c_{snp} of his salary. The computation of the pension P_{snp} follows the typical benefit rules in a Definite Benefit (DB) system: the insured receives at least a minimum pension (P_{min}) with a ceiling of P_{max}. Between the limits, the insured can reach a pension of value βY, with β being the replacement ratio. The value of β is calculated for every insured according to the regulation (see the appendix). In addition to the restrictions shown for enrolling into the SPP or SNP, we also have that $a, c_{spp}, c_{snp}, \beta \in (0,1)$ and $a + c_{spp} \in (0,1)$.

Once the optimal consumption plans are found for each choice, we obtain the indirect utilities as functions of income. $V_0(Y)$, $V_{spp}(Y)$, $V_{snp}(Y)$ are the indirect utilities for not-enrolling, enrolling in the SPP and in the SNP, respectively. We calculate the percentage of income required to leave an individual who is actually not enrolled as well off he would be enrolled but without this additional income. We call this measure the income equivalent variation (IEV). Thus, $IEV = \Delta Y / Y$ and its calculation is derived from:

$$V_0(Y(1+IEV_{spp})) = V_{spp}(Y) \tag{5}$$

$$V_0(Y(1+IEV_{snp})) = V_{snp}(Y) \tag{6}$$

For an individual that is already enrolled in the SPP, the procedure to calculate the IEV is similar. First, the individual finds the two optimal plans of consumption: i) he leaves the SPP at age x, so that he maximizes the equation 1 subject to equation 7; ii) he keeps enrolled to SPP, so that he maximizes equation 1 subject to equation 8. Second, the IEV are computed for each case with the equation 5 evaluated with the corresponding indirect utilities.

$$\sum_{t=0}^{D-x} C_t Z^{-t} = \sum_{t=0}^{R-x-1} YZ^{-t} + \sum_{t=R-x}^{D-x} P_{spp} Z^{-t} \tag{7}$$

$$P_{spp} = \frac{CIC_x (1+\tilde{r})^{R-x-1} + BR}{CRU_R} \tag{7'}$$

$$\sum_{t=0}^{D-x} {}_x p_t C_t Z^{-t} = \sum_{t=0}^{R-x-1} Y(1-a-c_{spp}) Z^{-t} + \sum_{t=R-x}^{D-x} P_{spp} Z^{-t} \tag{8}$$

$$P_{spp} = \frac{c_{spp} Y \sum_{t=0}^{R-x-1} (1+\tilde{r})^t + CIC_x (1+\tilde{r})^{R-x-1} + BR}{CRU_R} \tag{8'}$$

Equation 7′ indicates that the pension received by the individual at retirement age is composed by i) the resources and returns accumulated in his pension account (CIC_x) until he stops to contribute (i.e. age x), ii) the returns earned by these resources in the pension fund until the retirement age and iii) the value of the Recognition Bond[6] (BR). Equation 8′ shows that the pension is formed by all resources and returns accumulated by the individual since his enrolment date until the retirement age plus the BR.

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[6] In order to compensate the insured that shifts from the SNP to the SPP, the State entitles a Recognition Bond for the contributions made to the SNP. Some legal requirements have to be fulfilled to obtain this bond, which can be 1992 or 1996 type depending on the year used to account backwards for past contributions. The value of the bond is actualized by the prices index up to the date of retirement, and only at this date the bond is paid and deposited in the individual pension account.

Analogously, a person enrolled in the SNP must find the consumption plans if he leaves or keep enrolled in the SNP. In the first case, this person maximizes equation 1 subject to 9; and in the second case, the consumption constraint is equation 10. We obtain the IEV by evaluating equation 6 with the corresponding indirect utilities.

$$\sum_{t=0}^{D-x} C_t Z^{-t} = \sum_{t=0}^{R-x-1} YZ^{-t} + \sum_{t=R-x}^{D-x} P_{snp} Z^{-t} \tag{9}$$

$$\sum_{t=0}^{D-x} {}_x p_t C_t Z^{-t} = \sum_{t=0}^{R-x-1} Y(1-c_{snp}) Z^{-t} + \sum_{t=R-x}^{D-x} P_{snp} Z^{-t} \tag{10}$$

The only difference between equation 10 and 4 is the calculation of P_{snp} (see the appendix). Similar to Kotlikoff and Spivak (1981) and Brown (2001), we assume a CRRA utility function, which holds the standard assumption of inter-temporal separability[7]. And this is $U(C_t) = C_t^{1-\gamma} / 1-\gamma$, where γ is the parameter of relative risk aversion.

4. Data and elicitation of parameters

4.1 Data

We use the Social Risk Management Survey (PRIESO), which is a combined survey and large-scale economic field experiment conducted by the World Bank and applied in Peru during May 2002. It includes 1,002 individual respondents randomly drawn from the list of Lima-dwelling, working respondents from the *Encuesta Nacional de Hogares* (ENAHO) applied in the third quarter of 2001 (during August and September). However, when the interviewers could not contact the same individual who answered in ENAHO they replaced this person with another household member or with a member from other household. Unfortunately, the interviewers did not register the name and the gender of the replacement. Since the gender is an important variable that may affect individual decisions, we drop from the sample the observations that presumably are replacements[8].

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[7] Brown (2001) points out that this formulation rules out a number of alternatives such as habit formation, hyperbolic discounting, or the ability to separate out the effects of inter-temporal substitution and risk aversion. However, this is standard in the literature and it is less demanding on computing resources, particularly if we have to compute one or two IEV's for each individual in the sample for each simulation we run.

[8] Since the age is asked in both surveys and there are not more than 10 months of difference between the dates of their application, we only keep the observations where the age given in PRIESO minus that of ENAHO is 0 or 1 at most.

By doing so, we obtain a new sample of 789 individuals[9], which resembles the original sample in terms of distributions and means of key variables such as age and enrolment status. Likewise, we only consider the respondents who are not-enrolled or enrolled in the SPP or SNP, and exclude few cases that answered to be enrolled in other pension system. The respondent's current age has to be at least 20 because the official mortality table starts at that age. Furthermore, we exclude the respondents who are over 65 years old because the legal retirement age is 65. We also drop the individuals without income. After all these selections the sample consists of 638 individuals, which is composed by 173 not-enrolled and 465 enrolled in any pension system (331 in the SPP and 134 in the SNP).

The respondents of PRIESO participated in an experiment to measure attitudes to risk. The individuals are asked to choose between investing in firm A with profits in the form of a gamble or in firm B which offers a fixed profit. The interviewer repeats the question many rounds and increases the fixed profit in each round. Thus, the amount of fixed profit at which the choice of the firm is reversed indicates the certainty equivalent[10].

4.2 Parameterization

a) Risk aversion

The risk aversion parameter is estimated from the response of the individuals in the first experiment of PRIESO. Each respondent has to choose to invest in firm A, which offers a gamble composed by a low return of 8 Soles and a high return of 20 Soles (both with 50% of probability), or in firm B that offers a fixed return. The interviewer considers, first, a fixed amount of S/.8 for the firm B. If the respondent chooses the gamble, the interviewer must register the answer, increase the fixed amount by one extra Sol and ask again for the respondent's choice. This process continues until the respondent accepts the fixed amount proposed, which can be thought as the certainty equivalent. We infer the value of the risk aversion parameter by using the previously assumed CRRA utility function and the property $U(ce) = \theta U(x_1) + (1-\theta)U(x_2)$, where ce is the certainty equivalent and θ=0.5. The average of the certainty equivalent in the sample is 12.72[11] and hence the elicited risk aversion parameter is 0.98.

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[9] This sample size is similar to that of Brown (2001), which is composed by 869 persons.

[10] See Barr and Packard (2005) for more details on the experiment and the survey data of PRIESO.

[11] This number is obtained by subtracting 0.5 from the average of the fixed profit offered by firm B at which the respondent chooses firm B instead of firm A. We subtract 0.5 because the marginal increment made by the interviewer is of one monetary unit, but the actual switching might have occurred within the range of 0 to 1 Soles.

b) Mortality

At the time of application of PRIESO, the official mortality tables were the RV-85 and B-85 (both include different tables for men and women). The RV-85 is used to calculate the survival probabilities of the entitled pensioner whilst the B-85 is used for the beneficiaries of the pensioner (widow, non-adult children and parents). A spouse is the only possible pension beneficiary that we consider in the computation of the annuity price. We use ψ=0.42, which is the corresponding legal percentage for a widow or widower by default[12]. Within the group of head of households younger than 65 in the sample, the difference between the head and his spouse is 3.07. Thus, in the computation of the annuity price, we assume that the male entitled pensioner is 3 years older than his wife, and that the female entitled pensioner is 3 years younger than his husband.

The insurance companies have to use the official estimated mortality tables to calculate the annuity price, because they cannot foresee the exact mortality profile for each individual. However, the individual decisions concerning the optimal consumption path and enrolment may rely more on an individual perception about the own mortality profile. If this is the case, we should use individual subjective probabilities of surviving for all equations except for those used to calculate the annuity price. In PRIESO, individuals answer the question "until what age do you think you will live?" which may be used to measure life expectancy. Applying standard actuarial formulas and using a widely used type of Gompertz mortality function, we are able to estimate a new mortality table based on the subjective answers (see the appendix).

FIGURE 1: PROFILE OF OFFICIAL AND SUBJECTIVE SURVIVAL PROBABILITY FOR MEN

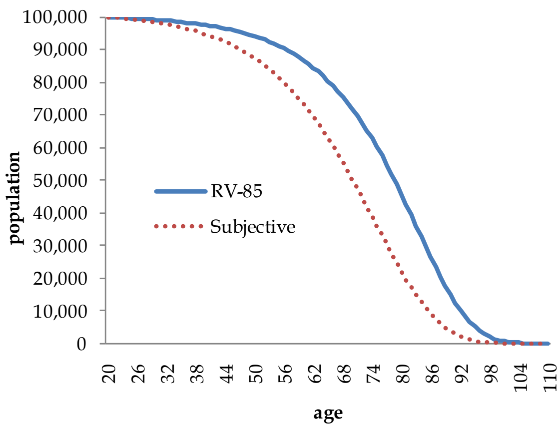
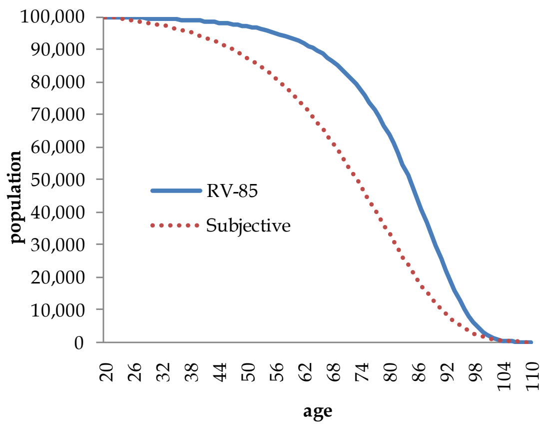


FIGURE 2: PROFILE OF OFFICIAL AND SUBJECTIVE SURVIVAL PROBABILITY FOR WOMEN



[12] In addition to data limitations, the possibility to have a non-adult child or living parents is low at retirement age and hence our assumption on a spouse as the only possible beneficiary is plausible.

Figure 1 and 2 show the discrepancies between the subjective and official mortality probabilities. By using the subjective and official mortality tables, one can see how a hypothetical population of 100,000 individuals at the initial age of 20 decreases as they become older and more exposed to the mortality risk. Clearly, the individuals believe their mortality is higher than it is assumed in the official tables[13]. Table 1 reports some survival probabilities calculated for men and women at a certain age. For instance, a 25 years old man believes that he has a probability of 0.634 to survive until age 65, but this number is 0.808 according to the official table. Likewise, according to general patterns the women show higher mortality than the men.

TABLE 1: SURVIVAL PROBABILITY

	Men		Women	
	RV-85	Subjective	RV-85	Subjective
for a 25 years old person:				
up to 45	0.965	0.923	0.983	0.922
up to 65	0.808	0.634	0.897	0.680
up to 85	0.297	0.109	0.480	0.218
for a 45 years old person:				
up to 45	1.000	1.000	1.000	1.000
up to 65	0.838	0.687	0.912	0.738
up to 85	0.308	0.118	0.488	0.237

c) Interest rates

Since the optimization programs implicitly presuppose no growth on prices, we must assume a pension fund interest rate free of price changes. We choose 5%, which is below the average of the yearly real pension fund calculated in each month between August 1994 and May 2002 (6.1%). The discounting interest rate and the time preference rate are also equal to the pension fund interest rate, i.e. 5%. Information on annuity interest rates in the Peruvian insurance market is hardly available. We set it as 4.6%, which is the rate specified in the regulation to evaluate the entitlement of some benefits (e.g. early retirement and minimum pension in the SPP).

d) Parameters of the pension systems

The contribution rates in the SPP and SNP were 8% and 13% of the salary respectively. Additionally, the individuals enrolled in the SPP have to pay an administrative fee and

[13] This is not surprising. Palacios and Rofman (2001) find a significant difference between the implicit mortality of the tables used in the pension systems and that of the tables used by the national institutes of statistics in Argentina, Chile, Colombia and Peru. Peru shows the largest discrepancy.

insurance premium, which both were 3.55% in average during May 2002. The maximum and minimum monthly pensions offered in the SNP were S/. 484 and S/. 1,000. In order to calculate the benefits in both pension systems, we need to make an assumption on the number of contributions actually paid to the pension system. According to available figures in the SPP, the average contribution density[14] in the SPP is 0.51. Therefore, this is the contribution density assumed in the computations of the benefits in the SPP. This assumption is also used in computation of the SNP benefits as there is not obtainable information on contribution density in the SNP[15]. An individual contributing roughly half of his working life is not far from more accurate figures of other similar pension systems, such as it is the case in Chile (Arenas de Mesa et al, 2008). Furthermore, we use the legal retirement age of 65 as the unique age to retire in our calculations. Although early retirement is possible under certain restrictive conditions in both systems, we rule out this possibility in order to simplify our computations and keep focus on the characteristics that affect the enrolment decision. Finally, the value of the pension fund balance and the BR at the time of PRIESO must be imputed for each individual (see the appendix).

5. Empirical results

5.1 Calibration results of IEV

The IEV is computed for each individual in the sample. If the individual is enrolled in one of the pension systems, the IEV is directly computed from the comparison between the indirect utility of being enrolled and leaving off the pension system. If the individual is not enrolled in any system, there will be two IEV. Only the higher of these two values is considered[16].

According to the assumed life-cycle approach, the individual always find optimal to acquire an annuity (i.e. enrol in pension system) in a fair annuity market. Since the administrative costs and insurance premium are charged in the SPP and the pensions in the SNP are calculated with pension rules, the annuity purchased or benefit obtained in

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[14] This is the average of the adjusted contribution density between January 1998 and February 2008. This is the quantity of contributors over the total of insured, excluding those who never contributed.

[15] The way the contribution density in the SPP enters into the equations is by multiplying it with the contribution rate c_{spp} where this appears. The contribution density in the SNP enters into the pension rules specified in the appendix.

[16] It means that the individual implicitly will choose the pension scheme that offers more gains in utility.

our optimisation programs is not "fair". Another source of unfairness is the discrepancy between the mortality used by the insurance firms to calculate benefits and the mortality considered by the individual in the optimization process, being the latter higher than the former. All these factors might erode the attractiveness of the enrolment and make optimal the decision of not-enrolment.

TABLE 2: IEV MEANS

Status	IEV (1)	IEV (2)	IEV (3)
Non-enrolled	0.120	0.189	0.200
Enrolled in SPP	0.102	0.181	0.202
Enrolled in SNP	0.581	0.709	0.709
Total	0.208	0.294	0.308

(1) It uses only the official mortality; (2) the survival probabilities are computed with the subjective mortality; (3) the survival probabilities and annuity prices are computed with the subjective mortality.

Table 2 shows the means of alternatives measures of the IEV. In the first column, the survival probabilities and the annuity price -needed for the computation of the IEV- are both calculated with the official mortality tables. In the second column, the survival probabilities are calculated with the subjective mortality and the annuity price is calculated with the official mortality table. In the third column, the subjective mortality and the annuity price are both calculated with the subjective mortality. Without subjective mortality, we would only be able to use IEV1 which is equivalent to assume that the mortality of the individuals follows the mortality of the official tables (like in Brown, 2001). However, by exploiting the information on subjective mortality computed from PRIESO and actuarial methods, we can calculate IEV2 which is a more accurate measure for the IEV. The difference between IEV2 and IEV1 shows that the underestimation of IEV might have been significant if we would not be able to use subjective mortality. If the insurance companies would use the subjective mortality to calculate the annuity prices, the annuities would be actuarially fair. A way to illustrate the size of the actuarial unfairness is compare IEV3 with IEV2[17]. We observe that the difference is not large, but IEV2 is still the preferred measure because it implies actuarial unfairness, which is closer to reality. Thus, the IEV2 is the value for the IEV that will be used henceforth.

According to the construction of the IEV, a negative (positive) value implies that the choice of not-enrolment (enrolment) is the optimal. However, only 6 individuals in the

[17] That comparison is not relevant for those individuals enrolled in the SNP since there are not annuity prices in this system.

sample have a negative IEV, which reveals that the option of enrolment in any pension system should be the optimal for almost everyone. Indeed, within the 173 individuals of the sample who are not-enrolled, 124 should optimally choose enrol in the SPP and 49 in the SNP (see table 3). Therefore, there must be some aspects apart from life-cycle considerations affecting the decision to participate in social security. Our hypothesis, as mentioned in the introduction, is that informal family arrangements should be accounted to better explain the resistance of individuals to insurance in social security.

TABLE 3: IEV MEANS FOR INDIVIDUALS WHO ARE NOT ENROLLED

		IEV (2)
Ind. who choose SPP	Mean	0.147
	#	124
Ind. who choose SNP	Mean	0.296
	#	49
Total	Mean	0.207
	#	173

It is instructive to observe the pension scheme preferred by the individuals. Table 3 shows that within the uninsured population, 72% prefer the SPP over the SNP. Likewise, table 4 shows that the profile of the uninsured that prefer the SPP or the SNP is different according to some of the characteristics included in the computation of the IEV. Attending only to very significant differences (at the 0.01 level) between group means, we observe that those who prefer the SNP are mainly men, younger and unmarried. Due to the minimum periods of contributions needed to obtain a pension in the SNP, the younger persons are the individuals that may find optimal to enrol in that scheme; and it is more likely that those individuals may still be unmarried. Although the differences in incomes were significant only at 15% confidence, the group that prefer the SPP shows higher incomes. Individuals with lower incomes prefer a system like the SNP that offers a minimum pension, and those who are richer prefer the SPP which is based on individual capitalization.

TABLE 4: VARIABLES' MEANS FOR INDIVIDUALS WHO ARE NOT ENROLLED

	Age	Male	Married
Individuals who choose SPP	36.766	0.395	0.597
Individuals who choose SNP	22.633	0.612	0.143
Total	32.763	0.457	0.468

5.2 Participation in the pension system

We run a probit model with a dependent variable that takes value 1 if the individual is enrolled in any pension system (SPP or SNP) and 0 otherwise. Similarly to Brown (2001), this may be interpreted as we only observe if the latent variable, i.e. the difference between the benefit and the cost of enrolment in social security, is greater than zero (taking value 1) or not (taking value 0). The group of independent variables is composed by the IEV computed for each individual and some covariates that might matter on the decision of enrolment in social security, such as demographics and family old-age arrangements. We assume that errors are normally distributed with zero mean.

The descriptive statistics of the sample are in table 5. Each column of the table 6 reports the regression results by adding a new set of covariates to the previous regression. The first column considers IEV as the only explanatory variable for the enrolment decision; its positive sign indicates that individuals are more likely to enrol if the benefit of enrolment increases. For instance, higher pension fund returns, lower commissions or more generous pension rules may increase the IEV and hence raise the probability of enrolment. Although the coefficient is significant, there is still a substantial amount of variation in the model to be explained.

TABLE 5: DESCRIPTIVE STATISTICS

Variable	Mean	Std. Dev.
Eenroled in pension system	0.729	0.445
IEV	0.315	0.572
Age	36.85	10.90
Male	0.599	0.491
Married	0.569	0.496
Income	1192.1	2285.9
Education: not	0.008	0.088
Education: primary	0.083	0.276
Education: secondary	0.436	0.496
Education: vocational	0.190	0.392
Transfers	0.058	0.234
Expected children	2.539	1.312
Expect to live in child's home	0.257	0.437
Expect to be cared by child	0.757	0.429
Extended family	0.431	0.496
Household size	5.226	2.299
Life expectancy diferential	-1.199	11.096

N=638, except for Life expectancy differential (N=630).

TABLE 6
MARGINAL EFFECTS FOR ENROLLING IN SOCIAL SECURITY (WITH ROBUST STANDARD ERROR)

Variable	(1)		(2)		(3)	
	dF/dx	s.d.	dF/dx	s.d.	dF/dx	s.d.
IEV	0.1753	0.0819 **	0.1039	0.0482 **	0.1009	0.0508 *
Age			0.0095	0.0024 ***	0.0105	0.0024 ***
Male			0.1162	0.0406 ***	0.1041	0.0411 ***
Married			0.0253	0.0366	0.0248	0.0389
Income			0.0001	0.0001	0.0001	0.0001
Education: not			-0.3290	0.2632	-0.2793	0.2710
Education: primary			-0.3812	0.1015 ***	-0.3615	0.1035 ***
Education: secondary			-0.1298	0.0539 ***	-0.1275	0.0537 ***
Education: vocational			0.0324	0.0499	0.0306	0.0508
Transfers					-0.1216	0.0812 *
Expected children					-0.0243	0.0143 *
Expect to live in child's home					-0.0345	0.0419
Expect to be cared by child					0.0534	0.0443
Extended family					-0.0276	0.0413
Household size					-0.0012	0.0095
Life expectancy differential					0.0026	0.0016 *
Observations	638		630		630	
Pseudo R2	0.017		0.164		0.180	
Log Likelihood	-366.57		-311.85		-302.15	

Dependent variable is the dummy variable indicating if the individual is enrolled in social security (=1) or not (=0). The marginal effects are calculated at sample means. *** indicates significant at 1%, ** at 5%, * at 10%.

In model 2, some demographics are added. The age and monthly gross labour income are continues variables whilst gender, marital status and education are dummy variables. The highest degree of education, i.e. university, is treated as the omitted variable. The finding that younger individuals show lower propensity to enrol may be explained by the fact that this group exhibits lower mortality in the near future, so that the enrolment is less attractive. Similarly, the women are less prone to enrol due to their lower mortality with respect to that of the men, which increases the annuity price and therefore reduces the pension amount. Although only primary and secondary education are significant among the education levels, the signs reveal that more educated people have more probability to enrol. Overall, this model explains much more variation than the one that only consider the life-cycle characteristics through the IEV variable.

The model 3 includes a set of *proxies* related to the existence of old-age family support. The dummy variable "transfers" indicates if the individual has received remittances and transfers from other persons or households during the last 6 months. The variable "expected children" are the total number of children (including the current ones as well) that the individual expects to have. We take advantage from two questions in PRIESO related to future plans of the respondent about his expected living arrangements and care during old age. The first dummy variable indicates if the individual expects to live in one of his children's home when he gets older; and the second one indicates if the individual expects to be taken care by any of his children when he will be no longer able to care by himself. "Extended family" indicates if there are relatives in the individual's household beyond the nuclear family. The "household size" is the number of members in the individual's household. Furthermore, we include the variable "life expectancy differential" which amounts to the difference between the subjective expected death age reported by the individual and that of his corresponding age-gender group. This variable is a proxy for health heterogeneity that might affect annuitization (Brown, 2001), or pension enrolment in our approach.

The statistically significant variables are "transfers", "expected children" and "life expectancy differential". The individuals receiving transfers might be engaged in a sort of family arrangement so that they are less interested in pension enrolment. If we accept that a high number of expected children indicate a desire to embark in an old-age family arrangement, then the econometric results suggest the existence of a substitution relation between social security and old-age family arrangements[18]. Although not significant, the expectation to live in one of the children's home and the expectation to be taken care of by any children during old age affects negatively and positively, respectively, the decision to enrol. These results suggest that the individual would like to live with his children but not to be a burden. Moreover, the respondents with larger life expectancy differential, which proxies them as a self-reported healthier persons, are more likely to enrol.

Overall, the addition of more covariates to the regression model allows to explain more variation. More important, the coefficient for IEV is statistically significant and positive through all models, which leads support to the idea that life-cycle considerations affect the decision to enrol. One percent of increment in the IEV raises the probability of enrolment by 18% if this is the only variable considered. However, the inclusion of more covariates reduces the marginal effect to approximately 10%. Although not conclusive, the results allow us to accept that old-age support plays a role on the decision to enrol and that this explanation can be complementary with a life-cycle approach. A likelihood ratio test conducted between the model with the full list of covariates and the same model but without the variable IEV may be illustrative about the importance of keeping the life-cycle characteristics to explain the decision of enrolment. We obtain a LR(1)=4.72 with p-value of 0.0298, so that we reject the null hypothesis that the effect of IEV is zero. Thus, it is also

[18] Although some endogeneity could be present in the variable for transfers, we rule out this possibility based in the econometric findings of Li and Olivera (2009).

important to include life-cycle considerations in our attempt to explain enrolment decisions.

5.3 Policy implications

A pension policy is defined as a change in one or more of the parameter values used to compute the IEV. The effect of the policy is measured through the change in the probability of enrolment due to the new value of the IEV. To carry on this analysis, we use the coefficients estimated in the last econometric model reported in table 6 (which we consider the baseline model) and replace the old IEV values for the new ones. The policy may be a direct intervention on the pension system or the effect of a broader policy. An increase of the minimum pension or more generous pension rules are examples of the first type of policy, whilst the increase of the pension fund return as a result of better regulation on capital markets or the decrease of administrative fees due to tax incentives are examples of the second type. The policies considered in this section are only a sample from a broader set, and arbitrary, but are instructive to highlight how the Government may help to raise the pension enrolment. Note that the analysis is only focused on the effects of policies on the behaviour of the individuals, fiscal costs and behavioural effects are not considered.

TABLE 7: EFFECTS OF POLICIES

Policy	IEV mean	Prob. of enrolment a/	% of additional enrolments b/
Baseline case	0.2943	0.7279	
1. Actuarial fairness	0.3080	0.7290	0.0
2. Reduction of adm. fee and insur. premium to 1.0%	0.3157	0.7299	0.0
3. Increase of yearly pension fund return:			
rate of 7%	0.3165	0.7302	0.0
rate of 8%	0.3327	0.7319	1.0
rate of 9%	0.3538	0.7342	3.1
rate of 10%	0.3816	0.7372	6.1
4. Increase of min. pension in the SNP to 50% (=726)	0.3587	0.7311	2.0
5. Increase of max. pension in the SNP to 50% (=1500)	0.2944	0.7279	0.0
6. Increase of the contribution ratio to 0.80	0.3826	0.7360	11.2
7. Launch of a minimum pension scheme in the SPP	0.3219	0.7302	0.0
8. Policy 6 and 7 together	0.4548	0.7391	12.2

a/ Mean of the probability evaluated for each observation
b/ With respect to the total of individuals to whom the baseline model predicted no enrolment.

Table 7 reports the results for some selected policies. For every policy the IEV of each individual in the sample is computed with the corresponding parameter values. The first column shows the average of the individual's IEV for each policy. The second column shows the average of the probability of enrolment evaluated with the new IEV. The last column reports the additional individuals –as a percentage of the total of individuals to whom the baseline model predicted no enrolment- that could enrol due to the policy[19].

The pension in the SPP may be actuarially fair if the same mortality tables are used to compute the survival probabilities and the annuity price. Thus the use of the subjective mortality table to calculate annuity prices, and then the IEV, may be thought as a policy oriented to make pensions actuarially fair. Although the IEV rises with the application of this policy, it has negligible results on the probability of enrolment. A reduction of the administrative fees and insurance premium from 3.55% to 1.0% has a similar small effect. However, the increase of the pension fund return can affect importantly the IEV and the probability of enrolment. For instance, a rate of 10% pushes up the IEV average from 0.294 to 0.382 so that 6.1% of the no enrolled individuals could decide to enrol. Although an increase of 50% of the SNP's minimum pension is significant –and its potential fiscal cost as well- there are not major effects on the probability of enrolment. Furthermore, the rise of the SNP's maximum pension has not effects, which might be explained by the fact that high income earners prefer a system like the SPP. The increase of the contribution density to 80% is the single policy with the most significant effects on the IEV value and the probability of enrolment. One might assume that the launch of a minimum pension scheme in the SPP similar to the SNP's may encourage individuals to enrol, but this is not the case for our calculations. However, when that policy is applied in conjunction with one directed to increase the contribution density, the effect on the probability of enrolment and particularly on the IEV is remarkable[20] (last row of table 7). Since the IEV is a utility based measure, an increase on that measure represents an overall welfare gain. Therefore, in addition to rank the proposed policies according to its effects on the probability of enrolment, we can also rank such policies by welfare considerations. If the social welfare function is of a utilitarian type, then the most welfare-enhancing policy is the application of a minimum pension guarantee in the SPP together with an improvement in the contribution density. As the policies affect individuals with different characteristics (income, age, sex, ettc.), other type of social welfare function will produce different ranks.

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[19] The cut-off of the predicted probability of enrolment for each individual is 0.5.

[20] In this hypothetical scheme, the insured must contribute for 20 years to any pension system and earn more than the minimum salary in order to be entitled a minimum pension, like in the SNP.

6. Conclusions

Despite the structural pension reform from PAYG to individual accounts pension systems undertaken in Latin American countries, a considerable number of workers are still uncovered by the pension system. Our hypothesis is that, apart from poverty and large informal sector, the existence of informal family arrangements might be one of the reasons behind the low levels of enrolment in the pension system. We choose the case of Peru to study the interplay between pension enrolment and family arrangements due to the availability of specific data that we demand and the prominence of traditional means of old age support.

We adapted a life-cycle approach to the characteristics of the Peruvian pension system and compute the utility based measure IEV (Income Equivalent Variation) for each individual in our sample. The IEV is the percentage of income required to leave an individual indifferent between the choice of enrolment and not-enrolment. This measure, together with some demographics and *proxies* for family arrangements are included in probit regressions that explain the enrolment decision in the pension system. In this way, we attempt to account for the effects of life-cycle considerations and family old-age support. Consistently, and considering different model specifications, the IEV and family arrangements help to explain the enrolment decision. The positive coefficient found for the IEV suggests that aspects that affect positively the IEV value (such as higher pension fund return, less administrative fees or more generous pension rules) raise the probability of enrolment. Indeed, our evaluation of the effects of some arbitrary pension policies supports it. Furthermore, old-age family support reduces the probability of enrolment. Thus, the life-cycle approach and old-age family support are both useful and complementary to understand the pension enrolment behaviour.

References

Arenas de Mesa, A. and Mesa Lago, C. (2006), “The Structural Pension Reform in Chile: Effects, Comparisons with other Latin American Reforms, and Lessons”, Oxford Review of Economic Policy, Vol. 22, No.1, pp.149-167.

Arenas de Mesa, A., D. Bravo; J. Behrman; O. Mitchell and P. Todd (2008), The Chilean Pension Turns 25: Lessons from the Social Protection Survey”. In: S. Kay and T. Sinha (eds.), Lessons from Pension Reform in the Americas. New York: Oxford University Press.

Barr, A. and T. Packard (2005), "Seeking solutions to Vulnerability in Old Age: Preferences, constraints, and alternatives for coverage under Peru's pension system" The Centre for the Study of African Economies Working Paper Series, N° 239.

Brown, J. (2001), "Private pensions, mortality risk, and the decision to annuitize", Journal of Public Economics, vol. 82(1), pp. 29-62, October.

Cameron, L. and D. Cobb-Clark (2008), "Do Coresidency with and Financial Transfers from Children Reduce the Need for Elderly Parents to Work in Developing Countries?", Journal of Population Economics, vol. 21(4), pp. 1007-1033.

Chetty, R. and A. Looney (2006), "Consumption Smoothing and the Welfare Consequences of Social Insurance in Developing Economies", Journal of Public Economics, vol. 90, pp. 2351-2356.

Cox, D., Z. Eser and E. Jimenez (1998), "Motives for Private Transfers Over the Life-Cycle: An Analytical Framework and Evidence for Peru", Journal of Development Economics, vol. 55, pp. 57-80.

Cox, D. and M. Fafchamps (2008), "Extended family and kinship networks: economic insights and evolutionary directions" in Handbook of Development Economics, Volume 4, (North Holland).

Davidoff, T., J. Brown and P. Diamond (2005), "Annuities and Individual Welfare", American Economic Review, vol. 95(5), pp. 1573-1590, December.

Hoddinott, J. (1992), "Rotten Kids or Manipulative Parents: Are Children Old Age Security in Western Kenya?", Economic Development and Cultural Change, vol. 40(3), pp. 545-565.

Holzmann, R., T. Packard and J. Cuesta (2001) "Extending Coverage in Multi-Pillar Pension Systems: Constraints and Hypotheses, Preliminary Evidence and Future Research Agenda". In: R. Holzmann and J. Stiglitz (eds.) New ideas about old age security: toward sustainable pension systems in the 21st century. Washington D.C.: The World Bank.

Jellal, M. and F.C. Wolff (2002) "Insecure old-age security", Oxford Economic Papers, Vol. 54, pp. 636-648.

Kotlikoff, L.J. and A. Spivak (1981), "The family as an incomplete annuities market", Journal of Political Economy, vol. 89, pp. 372–391, April.

Li, C. and J. Olivera (2009), "Voluntary affiliation to Peru's individual accounts pension system" International Social Security Review (2009) Vol. 62:3. pp: 23-48.

Morduch, J. (1995), “Income Smoothing and Consumption Smoothing”, Journal of Economic Perspectives, vol. 9(3), pp.103-114.

Palacios, R. And R. Rofman (2001), “Annuity markets and benefit design in multi pillar pension schemes: Experience and lessons from four Latin American countries" Social Protection Discussion Paper No. 107, The World Bank.

Rofman, R. and L. Lucchetti (2006), “Pension Systems in Latin America: Concepts and Measurements of Coverage”, Social Protection Discussion Paper No. 616, The World Bank.

Yaari, M. E. (1965), “Uncertain Lifetime, Life Insurance, and the Theory of the Consumer”, Review of Economic Studies, vol. 32(2), pp.137-50.

Appendix

A1. Computation of the pension in the SNP

Recall that $P_{snp} = Min\{Max(\beta Y_t; P_{\min}); P_{\max}\}$ and $P_{snp} > 0$ if $\beta > 0$, otherwise $P_{snp} = 0$. According to the SNP regulations that were in force up to 2002, the calculation of the value of β depends on the enrolment status and age of the individual (see next table).

VALUES OF β TO CALCULATE THE PENSION IN SNP

a) The Individual is not enrolled in any pension system and plan to enrol in the SNP:		
x	If $T_1 = (65\text{-}x)\varepsilon_{snp} - 20 \geq 0$	If $T_1 < 0$
≤29	$Min[(0.30+0.02T_1);1]$	0
30-39	$Min[(0.35+0.02T_1);1]$	0
40-49	$Min[(0.40+0.02T_1);1]$	0
50-54	0	0
≥55	0	0
b) The Individual is enrolled in the SNP and plan to remain there:		
x	If $T_3 = [(x\text{-}x')+(65\text{-}x)]\varepsilon_{snp} -20 \geq 0$	If $T_2 < 0$
≤29	$Min[(0.30+0.02T_2);1]$	0
30-39	$Min[(0.35+0.02T_2);1]$	0
40-49	$Min[(0.40+0.02T_2);1]$	0
50-54	$Min[(0.45+0.02T_2);1]$	0
≥55	$Min[(0.50+0.04T_2);1]$	0
c) The Individual is enrolled in the SNP and plan to leave off:		
x	If $T_3 = (x\text{-}x')\varepsilon_{snp} -20 \geq 0$	If $T_3 < 0$
≤29	$Min[(0.30+0.02T_3);1]$	0
30-39	$Min[(0.35+0.02T_3);1]$	0
40-49	$Min[(0.40+0.02T_3);1]$	0
50-54	$Min[(0.45+0.02T_3);1]$	0
≥55	$Min[(0.50+0.04T_3);1]$	0

Where:

x' : Age at which the individual enrolled in SNP.

ε_{snp}: Contribution density in SNP (share of contributions actually paid, $\varepsilon_{snp} \in [0,1]$)

A2. Subjective mortality table

The way to build a mortality table is to assume a given population that decreases year by year as result of the increasing mortality related to the ageing process. The tables RV-85 assume an initial population of 100,000 individuals at the initial age of 20, who "die" yearly until the last age considered (110). All the hypothetical population disappears beyond this age. The key variable in a mortality table is l_j, which is the number of living individuals at age j. The actuarial formula for the expected life expectancy at age x is $e_x = \sum_{j=x}^{109} l_j / l_x$, therefore an individual of age x expects to live until the age x + e_x. Rearranging terms, it is possible to show that:

$$l_x = \prod_{j=21}^{x} \frac{(e_{j-1} - 1) l_{20}}{e_j} \qquad \forall 21 \le x \le 109$$

Equipped with this formula, we can obtain the l_x variables based on the subjective answers on life expectancy given by the individuals, broken by gender and age. We average the additional extra years that a person expects to live by using the first sample of 789 respondents (in order to have better estimates). Since those l_x are far from showing a smooth declining as a typical mortality table, we adjust the results by using a Gompertz mortality function, a type widely used in the estimation of mortality tables (indeed, this function type is used in the RV-85): $l_x = sg^{C^X}$ where s, g and c are parameters to be estimated. The results of the non-linear regression are:

REGRESSION OF LX USING A GOMPERTZ FUNCTION

	Men			Women		
Variable	Coef.	Std. Err.	t	Coef.	Std. Err.	t
s	105242.5	7552.7	13.93	82010.13	7979.473	10.28
g	0.9968778	0.008898	112.04	0.9942536	0.019639	50.63
c	1.080426	0.047665	22.67	1.06804	0.056127	19.03
N. of obs.	47			46		
R-squared	0.9713			0.9701		

Dependent variable: lx

A3. Pension funds and Recognition Bond (BR)

We need the individual pension funds balance to calculate the benefits in the SPP (equations 7′ and 8′). Unfortunately, this information neither is available in PRIESO nor is accessible from the pension funds regulator due to its financial and confidential nature. Thus, we must impute the balances for each individual enrolled in the SPP. The procedure is simply; we use the salary of each individual to compute how many pension fund shares bought monthly between the date he enrolled in the SPP and May 2002. In that "purchase" of shares, we consider the corresponding contribution rates that were valid during the period, a contribution density of 0.51 and a yearly growth rate of salaries of 8.6%. This is the salary growth rate of blue-collars and white-collars of the private sector in Lima Metropolitana between August 1993 (starting date of the SPP) and June 2002. We apply this rate to the salary backwards from May 2002 to the date the individual enrolled in the SPP. Finally, the individual pension fund balance is the quantity of accumulated shares valued at the share price of May 2002.

We also need to impute the value of the BR to those workers who shifted from the SNP to the SPP. However, not all the workers who shifted pension systems can receive one of the BR types; they have to fulfil the corresponding regulations. For instance, to be entitled a BR type 92, the individual had to contribute at least 48 months before December 1992. Therefore, we only calculate the value of the BR for those individuals who, given their date of enrolment in the SNP and the assumed contribution density of 0.51 might have at least 48 contributions. According to the regulation, the value of the BR is determined as BR=0.1831*Y*M, where Y is the average monthly income in 1992 and M is the number of legally recognized contributions made in the SNP before December 1992. Again, we use the assumed salary growth rate of 8.6% and the contribution density of 0.51 to find Y and M respectively, and calculate the value of BR. Since this value is at December 1992 prices, we apply the price index accordingly to obtain the BR at prices of May 2002. The procedure used to obtain the BR type 96 is rather similar.