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Assessing Redistribution in the Uruguayan Social Security System

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Abstract

We assess redistribution in the Uruguayan main pension and unemployment insurance programs on a lifetime basis. Using administrative records from social security, we simulate lifetime declared labor income and flows of contributions and benefits of affiliates to the programs. Expected present values of income and net flows are also computed. Equipped with these estimations we construct standard measures of distribution and redistribution of lifetime labor income through the social security system. Our findings suggest that these programs reduce income inequality. In particular, social Security reduces the Gini coefficient of expected lifetime formal labor income by almost 2 percentage points.

Keywords: Redistribution; Social Security; Uruguay

JEL Codes: H55, J14, J26

Resumen

Evaluamos la redistribución en los principales programas de pensión y seguro de desempleo en el Uruguay, mirando al individuo a lo largo de la vida. Usando registros administrativos de la seguridad social, simulamos el ingreso por trabajo declarado a lo largo de la vida y los flujos de contribuciones y beneficios de los afiliados a los programas. Los valores presentes esperados del ingreso y los flujos netos también se computan. Con estas estimaciones construimos medidas de estándar de distribución y redistribución del ingreso laboral a lo largo de la vida a través del sistema de seguridad social. Nuestros resultados sugieren que estos programas reducen la desigualdad del ingreso. En particular, la seguridad social reduce el índice de Gini del ingreso laboral formal esperado a lo largo de la vida por casi 2 puntos porcentuales.

Palabras Claves: Seguridad Social; Redistribución; Uruguay

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1 Introduction

We assess redistribution in the Uruguayan main pension and unemployment insurance programs on a lifetime basis. Using administrative records from social security, we simulate lifetime declared labor income and flows of contributions and benefits of affiliates to the programs and compute the expected present values of income and net flows. Equipped with these estimations we compute standard measures of distribution and redistribution of lifetime formal labor income through the social security system. We find that these programs reduce income inequality. Social Security reduces the Gini coefficient of expected lifetime formal labor income by 1.8 percentage points.

This study is part of a regional project designed to assess redistribution of income in Argentina, Brazil, Chile, Mexico and Uruguay.[3] We use a similar methodology in the five countries in order to facilitate comparisons. This group of countries includes very different designs, ranging from the Chilean and Mexican savings accounts programs to the Argentinean and Brazilian PAYG programs, with Uruguay in the middle with its mixed program that incorporates both savings accounts and PAYG-DB pensions.

The Uruguayan social security program, as well as the other programs included in this regional project, incorporates explicit redistributive components. There is however some concern about the functioning of these programs in the context of high informality and frequent interruptions in the histories of contribution to social security. Forteza et al. (2009) and Bucheli et al. (2010) show that many contributors to the Uruguayan program may not be able to accumulate the thirty years of contributions that are currently required to access an ordinary pension. Moreover, Forteza and Ourens (2011) warn about the low rates of return that individuals with short histories of contribution may get from social security. Therefore, there is a risk that the program is less progressive in practice than it was initially thought and designed to be. The present study is an attempt to shed some light on this issue.

The paper is organized as follows. Section two presents the conceptual framework that guided this study and the whole regional project. We present a brief description of the

[3] The other country case studies are presented in Fajnzylber (2011), Moncarz (2011) and Zylberstajn (2011). Forteza (2011) presents a summary of the five country cases.

Uruguayan old age pension and unemployment insurance programs analyzed in this study in section three. Section four describes the data and section five presents the methodology. The results are presented in section six. The paper concludes in section seven with some final remarks.

2 Conceptual framework[4]

Social Security programs are usually designed to redistribute income from the better to the worse off. Most benefit formulas include explicit redistributive ingredients, like minimum pensions and supplements to small pensions. Even individual accounts DC programs, which are based on the principle of actuarial neutrality, tend to incorporate non-actuarial redistributive ingredients.

But social security programs also redistribute income through less explicit mechanisms. First, high mortality rates may reduce the returns low income workers get for their contributions in pension programs when unified mortality tables are used (Garrett, 1995; Duggan et al. 1995; Beach and Davis 1998; Brown et al. 2009).[5]

Second, government transfers that contribute to finance social security in many countries favor the population that is covered by the programs, which in developing countries tends to be the better off (Rofman et al. 2008). But also these same groups are the ones that pay more taxes, so the net effect is not clear (Forteza and Rossi, 2009). Ideally, we should trace the origin of the funds governments spend financing social security and include those taxes in the individuals' cash flows.

Third, low densities of contribution may leave many workers ineligible for benefits. Low income workers have been shown to have particularly low densities of contribution (Forteza et al. 2009; Berstein et al. 2006).

In this research project, we focus on this last channel, i.e. the redistribution stemming from the fact that low income workers tend to have systematically shorter contribution

[4] This section is taken from Forteza (2010).

[5] There is however contradicting evidence on the impact of differential mortality rates on social security progressiveness. Brown et al. (2009), for example, report very small effects on the measured progressivity of the US Social Security program of incorporating differential mortality rates by race and education.

histories. We do not assess the impact of different mortality rates and different coverage on implicit redistribution.

Social Security redistribution is often assessed on an annual basis, analyzing taxes paid and benefits received by different groups of contributors. This type of analysis tends to show large transfers among groups which depend mostly on the ratio of beneficiaries to earners within each group. But most individuals transit from earning income and paying contributions to receiving pension benefits along their lifecycle. Therefore, redistribution performed through social security can be better assessed adopting a lifetime perspective (Liebman, 2001).

We run micro-simulations of lifetime declared income and social security contributions and benefits to assess redistribution. We focus on intra-generational redistribution: one cohort, current pension rules. It is worth noticing though that social security performs inter- as well as intra-generational redistribution and that there is considerable evidence that inter-generational redistribution has been substantial, with early generations usually benefiting with high returns to contributions (Liebman 2001, Morató and Musto, 2010).

The indicator used in this study to analyze transfers is the social security wealth, defined as the net present value of the expected lifetime flows of contributions and benefits (Gruber and Wise, 1999, 2004; Coile and Gruber, 2001; Liebman, 2001, Brown et al. 2009). The progressivity of the system is assessed comparing the distribution of the expected pre- and post-social security lifetime income. Pre-social security lifetime formal labor income is the present value of formal income before contributions to social security and without benefits from social security. Post-social security formal income is the present value of lifetime formal income net of contributions to social security and including benefits from social security. The comparison is done with standard Lorenz and concentration curves, Gini indexes and an index of net redistributive effect.

We consider the individual as the unit of analysis, but it should be noticed that redistribution in the social security system may look very different at the family level. Gustman and Steinmeier (2001) show that, when analyzed at the individual level, the U.S. social security looks very redistributive, favoring low income workers, but it looks much less so at the family level (see also Lambert 1993, p 14). In the words of Brown et al. (2009): "…much of the apparent redistribution from Social Security occurs within, rather than between, households."

Ideally, the assessment of the redistributive impact of social security programs should be based on the comparison of income distribution with and without social security.[6] This is not the same as comparing pre- and post-social security income (i.e. income minus contributions plus benefits), because social security is likely to induce changes in work hours, savings, wages and interest rates. In this line, Huggett and Ventura (2000) simulate a fully fledged OLG model of Social Security calibrated with US data. Forteza (2007) follows a similar approach to study the redistributive impact of a social security reform in Uruguay. In a similar vein, albeit not to study redistribution, Jiménez and Sánchez (2007) estimate a structural life cycle model to assess the incentives to retire in the Spanish Social Security System. Auerbach and Kotlikoff (1987) represents a key reference in this line of inquiry. One possible drawback of these models is the assumption of full rationality, something that has been subject to much controversy, especially regarding long run decisions like those involved in social security. After all, the most used rationale for pension programs is individuals' myopia (Diamond, 2005, chap. 4). In principle, a model with hyperbolic preferences could do the job, but solving and calibrating these models is even more difficult than the already demanding standard optimization in full rationality models.

In turn, much of fiscal incidence analysis is done on the non-behavioral type of assumption. It is usually performed under the assumption that pre-tax income is not affected by the tax system. Because of this, it is often interpreted as an analysis of the impact effect of the fiscal system (Lambert, 1993, pp 153, 162, chap 11). One such example is Euromod. Sutherland (2001) warns: "EUROMOD is better-suited to analysing some types of policy and policy change than others. Since it is a static model, designed to calculate the immediate, "morning after" effect of policy changes, it neither incorporates the effects of behavioural changes (i.e. behaviour does not change) nor the long-term effect of change. Thus it is not the appropriate tool for examining policy that is only designed to change behaviour, nor for policy that can only have its impact in the long term (e.g. some forms of pensions policy). It is best-suited to the analysis of

[6] This is the equivalent to what Lambert (1993, p 266) suggests for the assessment of the impact of income taxes: "…the impact of an income tax can now be judged by comparing the "with-tax" income distribution with the distribution that would pertain in the tax's absence –the "no-tax" distribution rather than the "pre-tax" distribution." It is interesting to notice though, that ten of the eleven chapters of his classical book on distribution and redistribution of income are based on the assumption of invariant pre-tax income distribution.

policies that have an immediate effect and which depend only on current income and circumstances." We will be using life cycle models that are better suited to analyzing the redistributive impact of social security policies than the typical static short run models used in most microsimulations. However, following standard practice in microsimulations, we will not model behavioral responses. Our approach is closer to the literature pioneered by Gruber and Wise (1999, 2004), who designed and computed a series of indicators of social security incentives to retire assuming no explicit behavioral responses. Our study is also close to Liebman (2001) and Brown et al. (2009) who simulate lifetime income and compute redistribution in US Social Security using non-behavioral models.

In our view, these two approaches are largely complementary. The optimization models have the obvious advantage of incorporating behavioral responses, so not only the direct effects of policies are considered, but also the indirect effects that go through behavioral changes. However, in order to keep things manageable, these theoretically ambitious models necessarily make highly stylized assumptions regarding not only individual preferences and constraints, but also social security programs. Given our goals, this is a serious drawback. We want to assess the lifetime implicit transfers in social security given the observed histories of contribution in Latin American countries. We are only beginning to characterize the very heterogeneous and highly-fragmented histories of contribution which are present in the region (Forteza et al. 2009) and quite far from having optimization models that can fit these patterns. Whether these histories of contribution are optimal responses to social security rules and various shocks is something we cannot answer yet. But given social security rules, it is quite clear that these patterns of contribution seriously condition effective net transfers to social security. Non-behavioral micro-simulations are based on exogenously given work histories and geared to providing insights on the social security transfers that emerge from those histories. Thanks to their relative simplicity, non behavioral models allow for a much more detailed specification of the policy rules and work histories than intertemporal optimization models. An additional advantage of micro-simulations is that the effects are straightforward, so no black-box issues arise. At the very least, we can expect to capture the first-order impact effects of social security on income distribution.

The micro-simulation modeling can thus be seen as a first step in a more ambitious research program that incorporates behavioral responses in a more advanced phase.[7]

3 The Uruguayan pension and unemployment insurance programs

The Uruguayan old-age pension system is composed of five separate programs. The largest one is mixed, with a first PAYG-DB and a second individual savings accounts pillar. A public institution, the *Banco de Previsión Social* (BPS), collects contributions and administers the first pillar. Four private administrators, the *Administradoras de Fondos de Ahorro Previsional* (AFAP) manage the savings accounts. By 2001, this program covered about 90 percent of the total number of contributors to all social security institutions in the country (Ferreira-Coimbra and Forteza, 2004). The other four programs have more limited scope and cover specific groups of workers: bank employees, notaries, self-employed university graduates, armed forces personnel, and police force personnel. In this paper, we focus exclusively on the program administered by BPS-AFAP.

The mixed BPS-AFAP program was inaugurated in 1996, and is the result of reforms to the old PAYG-DB program, administered by the BPS. The old-age, survivors, disability and unemployment insurance programs served by BPS are financed with employee and employer contributions plus revenues from some ear-marked taxes. The government also contributes to the financing of this program covering deficits. Employer contributions are currently 7.5 percent and employee contributions are 15 percent of covered wages, but only part of employee contributions are allocated to the PAYG-DB pillar administered by the BPS. Depending on the wage level and options left to individuals[8], up to approximately half of employee contributions are deposited in savings accounts. Wages are covered up to a maximum that is monthly adjusted according to the average wage index (this maximum is currently equivalent to about

[7] An example of this strategy is the retirement research line followed by Jiménez and collaborators in the case of Spain (Boldrin et al. 1999, 2004; Jiménez and Sánchez, 2007).

[8] Individuals with low wages (less than about 1,265 dollars per month) are in principle served exclusively by the first pillar, unless they explicitly opt to participate also in the savings account pillar. No one is served exclusively by the individual savings accounts pillar.

3,800 dollars per month). A peculiarity of the Uruguayan social security system is that OASDI and unemployment insurance programs have a totally unified financing.
The old-age pension program provides two pensions, one served by the PAYG-DB pillar and the other by the savings accounts pillar. Eligibility in the PAYG pillar includes a minimum of 60 years of age and 30 years of contributions. At 65 years of age, individuals can claim the PAYG pension with 25 years of contributions. The required years of contribution are reduced at higher retirement ages, with a minimum of 15 years of contribution at 70 years of age. In the savings accounts pillar, individuals can start collecting their pension (received as an annuity) either once they are eligible to receive a pension from the PAYG pillar or when they have turned 65 years of age. Persons who do not satisfy the requirements to access a contributory pension may be eligible for a means-tested pension program.
The old-age pension in the PAYG pillar is computed multiplying the individual's average pension wage by the replacement rate. The average pension wage is the average of the indexed largest twenty years of wages covered by the PAYG pillar (or the last ten, if this is more favorable to the worker, up to a maximum of 1.05 times the best twenty). The replacement rate ranges from 45% to 82.5%, depending on the years of contribution and the retirement age. In addition, there is an extra bonus for low-income workers who choose to contribute to individual savings accounts.
Two explicit redistributive ingredients in the old-age pension program administered by the BPS and the AFAP are the minimum pension and the bonus paid to low income workers who explicitly opt to allocate part of their contributions to savings accounts. The minimum pension is currently set to about 185 dollars per month. Regarding the second mechanism, the PAYG pension of low wage individuals who explicitly opt to allocate half of their employee contributions to a savings account is increased by up to fifty percent.

The unemployment insurance program administered by the BPS covers all private sector dependent workers but workers in the financial sector, which have a separate program. The BPS unemployment insurance program covers three risks: dismissal, "*suspensión*" and reduction of the hours of work. There is a "s*uspensión*" when the firm needs to reduce employment temporarily and does not dismiss the "suspended" worker. A reduction of 25 percent or more of the hours of work is considered a cause of dismissal. Eligibility requires that the separation is not voluntary and that workers do not have other jobs, are willing to accept job offers, must have contributed at least six months in the last year, and did not use the program in the previous year. The benefit is 50 percent of the average wage in the previous six months, with a minimum equal to half the minimum wage, plus an additional 20 percent in the case of having dependent family. The benefit is paid during six months (Amarante and Bucheli, 2008).

4 Data

We used a random sample of the work history records of the main social security institution of Uruguay (BPS), collected in December 2004 by the Labor History Unit of the BPS (ATYR-BPS). Workers in the sample contributed at least one month between April 1996 and December 2004. The sample has close to 70,000 individuals.

This database provides detailed information about monthly contributions to social security, wages, and some characteristics of the job, including the date of initiation of activity and the explicit end of the link between the worker and the firm. It also has personal information of individuals: date of birth, sex and country of birth. A separate database contains information about benefits, including the date of retirement.

The administrative records do not have information about some important socio-economic characteristics like education and characteristics of the families. Also there is no information about other sources of income, including non-declared labor income.

5 Methodology

The methodology has four parts. First, we estimate the labor status and income models and simulated work histories. Second, we compute social security contributions and pensions. Third, we compute pre- and post-social security lifetime formal labor income. Fourth, we compute the income distribution and redistribution indexes.

5.1 Labor income and labor status models

We estimate models for labor income and working-contributing status, using a dynamic panel model of income and a linear probability model for the labor status. The two models are mostly independent, apart from the inclusion of the individual effects estimated in the income equation as regressors in the labor status regression. Multiplying formal labor income and the contributing status, we generate the series of work histories on which we base our estimations of labor income distribution and social security redistribution.[9]

We estimate and simulate models of formal labor, i.e. labor that is declared to social security. This is the relevant concept for the computation of social security benefits, but in the presence of high informality, this might be very different from total labor.

5.1.1 Projection of labor income

We estimate two labor income models: a dynamic panel data model for the second and following months of each spell of contribution and a static model for the first month. The dynamic model is as follows:

$$\ln w_{it} = \rho \ \ln w_{it-1} + \beta_1 \ln dur_{it} + \beta_2 a_{it} + \beta_3 a^2_{it} + \beta_4 \delta_t + v_i + e_{it} \qquad (1)$$

Where w_{it} is the ratio of the nominal wage of individual i at period t respect to the nominal wage index of the economy at period t [10]; dur_{it} is the tenure in the current job; a_{it} stands for age; δ_t are month dummies; and v_i is a time invariant unobservable characteristic of individual i. The idiosyncratic shock e_{it} is assumed to be normally distributed with mean 0 and variance σ^2_{it}.

The individual effects v_i are meant to capture the heterogeneity that comes from education and ability. Once the model was estimated, the individual effects were computed as follows:

$$\hat{v}_i = \frac{1}{T_i}\sum_{t=1}^{T_i}\left(\ln w_{it} - \left(\hat{\rho}\ln w_{it-1} + \hat{\beta}_1 ldur_{it} + \hat{\beta}_2 a_{it} + \hat{\beta}_3 a^2_{it} + \hat{\beta}_4 \hat{\delta}_t\right)\right) \qquad (2)$$

Predicted values of labor income were calculated as follows:

$$\ln \tilde{w}_{it} = \hat{\rho}\ln \tilde{w}_{it-1} + \hat{\beta}_1 ld\tilde{u}r_{it} + \hat{\beta}_2 a_{it} + \hat{\beta}_3 a^2_{it} + \hat{\beta}_4 \delta_t + \hat{v}_i \qquad (3)$$

We estimate the following model for the first month of each spell of contribution:

$$\ln b_i = \alpha_1 + \alpha_2 a_i + \alpha_3 a^2_i + \alpha_4 \hat{v}_i + \varepsilon_i \qquad (4)$$

[9] The methods used in this study are adapted from Forteza et al. (2009).

[10] This is inspired in Bosworth et al. (1999).

Where b_i is the average real wage, a_i is the age and $\hat{v}_i$ is the individual effect estimated with equation (1). We use the OLS estimator with the White formula in order to obtain the standard errors. Predictions for the first month are thus computed as:

$$\ln \tilde{b}_i = \hat{\alpha}_1 + \hat{\alpha}_2 a_i + \hat{\alpha}_3 a^2{}_i + \hat{\alpha}_4 \hat{v}_i \tag{5}$$

For this prediction, $\hat{v}_i$ is estimated from equation (1) while the remaining parameters come from equation (4).

5.1.2 Projection of the contribution status

We used a fixed effects linear probability model to project the contribution status. Besides its simplicity, the linear probability model has the advantage – compared to non-linear models –, that the individual effects can be computed. These effects are essential for projection purposes, particularly so when the database does not have sufficient socio-economic characteristics to capture heterogeneity, as it is the case with administrative data.[11]

The dependent variable is equal to one if the individual makes a contribution during a particular month and zero otherwise $(C_{it} \in \{0,1\})$. We allowed for two independent equations, depending on whether the individual was contributing or not in the previous month:

$$\begin{aligned} C_{it} &= x_{it}'\beta^0 + \eta_i^0 + \varepsilon_{it}^0 \quad if \quad C_{it-1} = 0 \\ C_{it} &= x_{it}'\beta^1 + \eta_i^1 + \varepsilon_{it}^1 \quad if \quad C_{it-1} = 1 \end{aligned} \tag{6}$$

Where x_{it} is a set of independent regressors, η_i is the individual effect and ε_{it} is an idiosyncratic shock.

The individual effects in the contribution status equations are computed as:

$$\hat{\eta}_i^s = \frac{\sum_{t=2}^{T_i} \left(C_{it} - x_{it}'\hat{\beta}^s\right) \mathrm{I}(C_{it-1} = s)}{\sum_{t=2}^{T_i} \mathrm{I}(C_{it-1} = s)} \;;\; s \in \{0,1\}.$$

Where $\mathrm{I}(C_{it-1} = s) = 1 \; if \; C_{it-1} = s; \; 0 \; otherwise$.

[11] For models of contribution status using duration models see Bucheli et al. (2010).

The set of variables included as regressors are: (i) age (cubic polynomial); (ii) dummy “elderly” that equals 1 if individuals are 60 or older; (iii) dummy “young” that is 1 if individuals are 25 or younger; (iv) the rate of unemployment; and (v) the estimated individual effects in the labor income equations $(\tilde{v}_i)$. The latter regressor is important as it links labor income and contribution status in the simulations.

We need an additional equation to project the contribution status in the first period. We assume that individuals start contributing at 18 and estimate a static contribution-status equation at that age:

$$C_{it} = y_{it}'\alpha_1 + \hat{\eta}_i'\alpha_2 + e_{it} \tag{7}$$

In this equation we include as regressors: (i) age (square polynomial), (ii) the rate of unemployment, and (iii) the individual effects computed in the dynamic equations $(\hat{\eta})$.

We simulate the contribution status of workers across their lifetime conditional on the individual not retiring or passing away. Simulations start at the age of 18. We determine the contribution status for the first month using equation

(7) and for the following months using equation

(6). More specifically we simulate the probability of contributing $\left(\tilde{P}_{it} = Pr(C_{it} = 1)\right)$, draw realizations from a uniform (0,1) distribution $(draw_{it})$ and set C_{it} as: $\tilde{C}_{it} = 1\ if\ draw_{it} < \tilde{P}_{it}\ and\ 0\ otherwise.$ In turn, the simulated probability of contributing is computed as:

$$\tilde{P}_{it} = y_{it}'\hat{\alpha}_1 + \hat{\eta}_i'\hat{\alpha}_2 \quad if \quad t = 1$$

and:

$$\tilde{P}_{it} = x_{it}'\hat{\beta}^0 + \hat{\eta}_i^0 \quad if \quad \tilde{C}_{it-1} = 0 \ \ ; t \geq 2$$
$$\tilde{P}_{it} = x_{it}'\hat{\beta}^1 + \hat{\eta}_i^1 \quad if \quad \tilde{C}_{it-1} = 1 \ \ ; t \geq 2$$

We compute the percentage of correct predictions in the sample to assess the goodness of fit of the models.

5.2 Computation of SS contributions and benefits

Using the simulated work histories, we compute social security contributions and benefits according to the existing social security norms. We consider two social security programs, old-age pensions and unemployment insurance. Contributions to these two programs are bundled together in Uruguay, so we cannot separate their impact on inequality. As in most countries, old age pensions are also integrated with disability and survivors insurance. Due to the lack of information about family composition and the incidence of disability, we focus on old-age pensions, assuming the simulated individuals leave no survivors and suffer no disability. We assume individuals claim benefits as soon as they are eligible.

We also simulate a scenario in which vesting period conditions are not fully enforced. In this alternative scenario, individuals who claim and receive pensions without having fulfilled the years of contribution legally required are assumed to receive minimum pensions. The aim of simulating this weak enforcement scenario is twofold. First, we want to assess the impact of vesting period conditions on social security progressiveness. Second, this scenario is a stylized representation of actual practices in an institutional environment in which the testimony of witnesses to credit contributions is still common practice.

5.3 Computation of pre- and post-social-security lifetime formal income

The expected pre-social security lifetime formal labor income is the present value of the expected simulated formal labor income:

$$\overline{W}(r) = \sum_{a=0}^{a=r-1} p(a) W(a) (1+\rho)^{-a}$$

Where r is age at retirement, $p(a)$ is the probability of worker's survival at age a, $W(a)$ is pre-social security formal labor income at age a, and ρ is the discount rate. Pre-social security formal labor income was computed as income before paying both employee and employer contributions. This assumes a perfectly elastic labor demand, which is a common assumption for this type of analysis, as contributions eventually impact on net wages in the long run (Gruber, 1999, p 90; Brown et al. 2009, p 13; Hamermesh and Rees 1993, p 212).

In a base case scenario, we assume the discount rate is 3 percent per annum (ppa), but we also simulate scenarios with 1 and 2 ppa. It has been argued that social security lifetime transfers are smaller the higher the discount rate, partly because of the social security wealth reduction it involves, but also because most social security programs perform redistribution through benefit rather than contribution formulas. Because of this, in their analysis of the redistributive impact of the US social security system, Brown et al. (2009) use 2 and 4 ppa. Liebman (2001) uses the internal rate of return of the cohort he analyzes -1.29 ppa- in order to focus only on intra-cohort redistribution, but he also presents results with higher discount rates.

We assume that social security does not impact on the age at retirement, so we used the same value of r to compute the pre- and post-social security labor income. We only depart from this assumption in the weak enforcement scenario, in which all individuals are assumed to retire at the minimum retirement age. Also we assume that the interruptions in labor history are exogenously given, independent in particular of the unemployment insurance program.

Lifetime social security wealth is the indicator computed to account for social security transfers. It is defined as the sum of the discounted expected flow of old-age pensions (PB) and unemployment benefits (UB), net of contributions (SSC).

$$SSW = PB + UB - SSC$$

$$PB = \sum_{a=r}^{a=\max\ age} p(a)B(a,r)(1+\rho)^{-a}$$

$$UB = \sum_{a=0}^{a=r-1} p(a)UB(a)(1+\rho)^{-a}$$

$$SSC = \sum_{a=0}^{a=r-1} p(a)C(a)(1+\rho)^{-a}$$

Where $\max age$ is maximum potential age, $B(a,r)$ is the amount of retirement benefits at age a conditional on retirement at age r, $UB(a)$ is the unemployment benefit collected at age a, and $C(a)$ is the amount of contribution at age a to social security.

The formulas used in this study to compute social security wealth are adapted from the literature that studies incentives to retire (e.g. Blanchet and Pelé, 1999, p132). Similar expressions are used in the literature that analyzes lifetime redistribution in social security (e.g. Liebman, 2001).

5.4 Computation of income distribution indexes

As a first step to characterize the redistributive impact of social security, we first present some descriptive statistics of lifetime expected pre-social security formal labor income, social security wealth and the social security wealth to pre-social security income ratio. These indicators do not provide a direct measure of the change in inequality that social security brings about, but are only a first assessment of the degree of redistribution taking place within the social security system.

In order to informally assess local progressiveness in social security, we plot individual social security wealth versus pre-social security formal labor income. A negative slope is a sign of progressiveness. Liebman (2001) presents similar plots for the US.

We then turn to global measures of progressiveness. We compute the Lorenz curves of the expected pre-social security formal labor income and the associated concentration curves of the expected post-social security formal labor income (ranked by pre-social security income). We also compute the Gini index of the pre- and post-social security formal labor income and 95% confidence intervals.

Finally, we compute the Reynolds-Smolensky index (RS) of net redistributive effect (Lambert, 1993, p 256). This index measures the redistributive impact of a program computing the area between the Lorenz pre-program income and the concentration post-program income. A positive (negative) value indicates that the program reduces (increases) inequality.

The estimation of the Lorenz and concentration curves and of the Gini and RS indexes was done using DASP (Araar and Duclos 2009).

6 Results

6.1 The labor income and contribution status models

We present the labor income regressions in Table 1. The equations for the second and following months of each spell of contributions show, as expected, a highly significant autoregressive component, ranging from about 0.5 to almost 0.7. Therefore, there is considerable persistence. Duration in the spell of contribution also has a positive impact on wages (albeit not statistically significant in the case of women in the private sector) and the coefficients multiplying age and age squared are significant at 1% in all cases, positive for age and negative for age squared. The labor income plot is thus concave in age.

Labor income in the first month of the spells of contribution does not show the same pattern in the four categories. Only in the case of women does initial labor income look concave in ages. In the case of men working in the public sector, age does not seem to have a significant impact on initial labor income and in the case of men working in the private sector, initial labor income appears to be convex in age. In all cases, the individual effect computed in the equation for the second and following months enters in the equation for the first month with positive and statistically significant coefficients.

The equations for the contribution status are presented in Table 2. Age enters in the regressions for individuals aged 19 and above through a cubic polynomial and two dummies. Figure 1 summarizes the age-profiles of the contribution probabilities according to the models. In the same figure, we also plot the observed frequencies of contribution. The regressions seem to replicate observed frequencies quite well in the case of public sector workers, but less so in the case of private sector workers. The rate of unemployment exhibits the expected negative sign in some but not all equations. The individual effects from the labor income equations (υ) exhibit the expected positive sign, significant at 1%, in all cases. This means that individuals who get higher labor income when they contribute also have higher probability of contributing. The Adjusted-R2 of these equations is very low. Regressions for the contribution status at age 18 show higher Adjusted-R2, but some of the results are rather unexpected. Only among men in the private sector does the rate of unemployment show the expected significant negative coefficient. Also the individual effects from the contribution status regressions for age 19 and above show the expected positive sign in the case of public sector workers, but a negative sign among private sector workers. Notwithstanding, the goodness of fit as measured by the percentage of correct predictions in within sample simulations is satisfactory (Table 3).

6.2 The redistributive impact of social security

We present in Table 4 some descriptive statistics of the simulated database. Average expected lifetime pre-social security labor income is 175 thousand dollars, ranging from 110 among women in the private sector to 364 among men in the public sector. On average, public sector workers earn more than twice as much as their private counterparts.

The simulated database exhibits much dispersion of income, which is central to effectively assess redistribution. There are some simulated individuals with very low lifetime income. The percentile one individual (P1) has about 500 dollars in the case of women working in the private sector. These women receive small income when they work but, more importantly, they have very short histories of contribution. Other categories exhibit higher P1 incomes, but even among men in the public sector, which exhibits the highest P1 income, it is smaller than 4,500 dollars. In interpreting these results, it is important to keep in mind that we are considering only formal lifetime labor income. We have no information about other sources of income, so we did not model or simulate income individuals may obtain in the informal sector. At the other end of the distribution, the percentile 99 individuals (P99) range from about 750 to almost 1,600 thousand dollars. As expected, the distributions are skewed to the right, with median consistently lower than mean income.

Average social security wealth ranges from minus 18 thousand dollars among men in the public sector to 2.3 thousand dollars among women in the private sector. Measured by the difference between percentiles 1 and 99 within each category, social security wealth exhibits the highest dispersion among men in the public sector (96 thousand dollars) and the lowest among women in the private sector (65 thousand dollars). The minimum P1 is minus 86 thousand dollars and takes place among men in the public sector. The maximum P99 is almost 20 thousand dollars and takes place among women in the private sector.

The individual social security wealth to income ratio is on average 8%.[12] The lowest average is -3% among men in the public sector and the highest is 19% among women in the private sector. There is much dispersion in this ratio, as the percentile one individual (ranked by the ratio) losses 13% and the percentile 99 gains almost 150% of their lifetime declared income.

According to these results, social security performs much redistribution. Whether this redistribution reduces inequality depends on how these transfers are correlated to lifetime income. We turn now to this point.

Figure 2 plots social security wealth and pre social security lifetime formal labor income. To facilitate comparisons between categories, we limit income in the figure to the minimum P1 to the maximum P99 range. The negative slope of the plots suggests that social security is progressive. However, there is considerable dispersion of social security wealth for each income level. Liebman (2001) reports a similar finding for the US.

The concentration curve of post-social security formal income is closer to the 45° line than the Lorenz curve of pre-social security formal income, showing that social security reduces inequality (Figure 3).

The Gini coefficient of the simulated pre social security life time formal labor income is 0.60 for the total population (Table 5). According to this indicator, the distribution of the income measure considered in the present study is much more unequal than the distribution of current household per capita income reported to household surveys.[13] In addition, inequality is much higher among private than public sector workers. The Gini of lifetime income is in the order of 0.6 among private and 0.4 among public sector workers.

[12] Liebman (2001) computed the same indicator for the United States. Using a discount rate of 3 percent per annum -the same rate used in the present study-, he finds the average ratio to be -6.6%.

[13] CEDLAS and The World Bank (April 2011), for example, report Gini coefficients estimated on 2009 household per capita income of 0.44. These indicators are not directly comparable to ours though. The Ginis reported in the present study refer to individual income as opposed to household per capita income, to labor as opposed to total income, to formal (in the sense of reported to social security) as opposed to formal plus informal income, and to simulated expected lifetime as opposed to reported current income.

According to these simulations, social security reduces inequality in Uruguay, causing a 1.8 percentage points drop in the Gini coefficient of expected life time formal labor income (Table 5). The RS index of net progressiveness is 1.9, significant at the usual significance levels (Table 6). Inequality falls in the four categories, but it is among women in the private sector that we obtain the largest fall, reaching 3 percentage points.

6.3 Weak enforcement and non-contributory old age pensions

We consider two extensions of the basic simulation scenario in this section. The first consists of simulating a scenario of weak enforcement, i.e. a scenario in which pension eligibility conditions are not fully enforced. The second is a scenario in which we incorporate non-contributory old age pensions.

6.3.1 Weak enforcement

There is considerable evidence that the administration does not fully enforce the eligibility conditions to access to contributory old-age pensions in the social security system administered by the BPS. Forteza (2003) reports anecdotal but also some normative evidence that suggests that the testimony of witnesses to certify that individuals claiming pensions fulfill the vesting period conditions is common practice. This anomaly is possible because of the failure of the administration to keep records of contributions. In turn, Bucheli et al. (2010) and Forteza et al. (2009) show that large segments of the population have a low probability of having contributed the number of years required to access to contributory pensions. These results contradict the high coverage that this program has among the elderly according to household surveys. One possibility, of course, is that the estimated probabilities are wrong, but the existing evidence on the contribution densities is in line with those estimations, suggesting that many individuals are receiving old-age contributory pensions without having actually fulfilled the vesting period conditions. In so far as short histories of contribution seem to be particularly frequent among low income individuals (Bucheli et al. 2010), the *de facto* loosening of the access conditions is likely to raise the progressivity of the social security system.

In order to assess the potential impact of this practice on inequality, we simulate a weak enforcement scenario. In this scenario, the vesting period condition is not required in practice. The assumption is that everybody can claim an ordinary pension at the minimum retirement age (60 years old). Individuals who did not contribute thirty or more years at that age receive the minimum pension. The results of this scenario are summarized in Table 7 to 9.

As expected, social security looks more progressive in the weak than in the strict enforcement scenario. Social security causes a 2.6 points fall in the Gini coefficient in the weak against 1.8 in the strict enforcement scenario. The RS is now 2.63 percentage points.

6.3.2 Non-contributory old-age pensions

In this scenario, we add non-contributory to the contributory old age pensions. We consider this scenario to make our results more comparable to the results reported by Fajnzylber (2011) for the Chilean case. As already mentioned, the present and Fajnzylber's paper are part of a joint effort to assess the redistributive impact of social security in Latin America. In Chile, after the 2008 reform, the non-contributory program is fully integrated to the contributory individual savings accounts program. Because of this, Fajnzylber's analysis integrates the non-contributory and contributory components in his assessment of redistribution in the Chilean pension system.

We did not compute taxes individuals pay to finance non-contributory pensions, so our analysis regarding the redistributive impact of non-contributory pensions is closer to an expenditure incidence analysis than to the net-fiscal-system type of analysis we did for the contributory program (Lambert, 1993).[14]

Unlike in the previous subsection, we assume again that the social security norms are strictly enforced. Individuals are eligible to receive the non-contributory pension (*Pensión por Vejez)* at age 70, provided they did not reach before the necessary number of contributions to retire and receive a contributory pension. We assume that individuals retiring through this program will receive the minimum pension. Summary results are presented in Table 10.

As expected, social security looks more progressive when non-contributory pensions are included. There is a fall in the Gini coefficient of 3.1 points compared to the 1.8 fall we

[14] In the real world, when the contributory program is partially financed by the government from the general budget, the distinction between contributory and non-contributory programs is more blurred than what the definitions suggest. This is the case of the program administered by the BPS. We made no attempt to compute taxes individuals pay to finance the contributory pensions program.

obtain when only contributory pensions are included. The RS is now 3.1 percentage points.

6.3.3 Other scenarios

We also run scenarios with lower discount rates. Using 1 and 2 ppa rather than the 3 ppa discount rate used in the base case scenario, we got more redistribution and more reduction of inequality. The general picture, however, does not change much.[15]

7 Concluding Remarks

The Uruguayan social security system redistributes income on a lifetime basis. The net effect of this redistribution is a reduction in inequality: the Gini coefficient of simulated post-social security lifetime formal labor income is about 1.8 percentage points lower than of pre-social security income. Social security looks more redistributive when non-contributive pensions are included: the Gini falls by about 3.1 percentage points when this program is included in the simulations. Also the program could be considerably more progressive than what the base-case scenario suggests because of the de facto loosening of the eligibility conditions. We get a 2.6 fall in the Gini coefficient due to social security when we assume that all individuals who have contributed less than 30 years receive the minimum pension when they turn 60.

The impact of the Uruguayan social security system on inequality is similar to the Brazilian (Zylberstajn 2011), but smaller than the Chilean. Using a similar methodology, Fajnzylber (2011) reports a four point drop in the Gini coefficient of life time income due to social security in Chile. The dispersion of social security wealth that can be observed at each level of life time income suggests that much redistribution in the Uruguayan program fails to reducing inequality.

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[15] The results of this additional scenario are available from the authors upon request.

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Tables

Table 1: Labor income regressions

A) Equation (1): $\ln w_{it} = \rho \ \ln w_{it-1} + \beta_1 \ln dur_{it} + \beta_2 a_{it} + \beta_3 a^2_{it} + \delta_t + v_i + e_{it}$

Independent Variables	*Men*		*Women*	
	Private Sector	*Public Sector*	*Private Sector*	*Public Sector*
$\ln w_{it-1}$	0.647***	0.513***	0.682***	0.562***
Log of Duration	1.123***	3.604***	0.0494	3.210***
Age	0.065***	0.208***	0.019***	0.178***
Age^2	-0.013***	-0.019***	-0.003***	-0.016***
Constant	0.872***	1.063***	0.702***	0.845***
Nº of Observations	1522832	389724	1137006	414016
Nº of Individuals	30625	4967	23930	5187
R-squared	0.509	0.38	0.546	0.413
Standard Deviation of v_i	0.332	0.337	0.353	0.282
Standard Deviation of e_{it}	0.292	0.277	0.268	0.280

Note: * significant at 10%, ** significant at 5%, *** significant at 1%. w_{it} is the ratio of the nominal wage of individual i at period t respect to the nominal wage index of the economy at period t. Duration is divided by 100. Age is measured in years and is divided by 10. Age^2 is divided by 100. Monthly dummies were included. * significant at 10% ** significant at 5% *** significant at 1%.

Source: Authors' computations.

B) Equation (2): $\ln b_i = \alpha_1 + \alpha_2 a_i + \alpha_3 a^2_i + \alpha_4 \hat{v}_i + \varepsilon_i$

Independent Variables	*Men*		*Women*	
	Private Sector	*Public Sector*	*Private Sector*	*Public Sector*
v	0.886***	1.621***	1.394***	1.721***
Age	-0.227***	-0.072	0.087***	0.462***
Age^2	0.015***	0.013	-0.013***	-0.045***
Constant	2.806***	3.102***	2.342***	2.161***
Nº of Observations	38,086	1,184	22,050	1,805
R-squared	0.051	0.199	0.31	0.327

Note: * significant at 10%, ** significant at 5%, *** significant at 1%. b_i is the average of the nominal wage of individual i at period t relative to the average wage index of the economy in the first 12 months of the contribution spell. Age is measured in years and is divided by 10. Age^2 is divided by 100. v is the individual effect computed in equation (1).

Source: Authors' computations.

Table 2: Contribution Status

A) Equation(1): $C_{it} = x_{it}'\beta^0 + \eta_i^0 + \varepsilon_{it}^0 \;\; if \;\; C_{it-1} = 0$; $C_{it} = x_{it}'\beta^1 + \eta_i^1 + \varepsilon_{it}^1 \;\; if \;\; C_{it-1} = 1$.

Age 19 and above.

	Men			
	Private Sector		*Public Sector*	
	Previous period status		*Previous period status*	
Independent Variables	*Contribute*	*Not Contribute*	*Contribute*	*Not Contribute*
Age	0.0030***	0.0003***	0.0019***	0.0011***
Age^2	-5.4702***	-0.6942***	-3.2270***	-2.2170***
Age^3	0.3270***	0.0394***	0.1810***	0.1291***
Elderly	-0.0219***	-0.0089***	-0.0105***	-0.0173***
Young	0.0218***	0.0014	0.0042***	-0.0006
Unemployment	-0.0001***	-0.0041***	0.0002***	-0.0017***
v	0.0171***	0.0125***	0.0105***	0.0073***
Constant	0.4449***	0.0696***	0.6425***	-0.1055***
Nº of Observations	1804203	1067089	406957	52446
R-squared	0.013	0.004	0.016	0.006
	Women			
	Private Sector		*Public Sector*	
	Previous period status		*Previous period status*	
Independent Variables	*Contribute*	*Not Contribute*	*Contribute*	*Not Contribute*
Age	0.0037***	-0.0001*	0.0035***	0.0022***
Age^2	-6.9370***	0.1790*	-6.4188***	-4.0546***
Age^3	0.4226***	-0.0134*	0.3880***	0.2313***
Elderly	-0.0322***	-0.0013	-0.0266***	-0.0119
Young	0.0256***	0.0040***	0.0122***	0.0169***
Unemployment	0.0007***	-0.0026***	0.0003***	0.0015***
v	0.0113***	0.0106***	0.0139***	0.0132***
Constant	0.3286***	0.0872***	0.3880***	-0.3312***
Nº of Observations	1313013	979173	434479	67814
Adjusted R-squared	0.016	0.003	0.024	0.006

Note: * significant at 10%, ** significant at 5%, *** significant at 1%. Age is measured in months. Age^2 is divided by 1,000,000 and Age^3 is divided by 100,000,000. Elderly is a dummy equal to 1 if the individual is 60 years or older. Young is a dummy equal to 1 if the individual is 25 years or younger. Unemployment is the country's unemployment rate. v is the individual effect computed in the wage equation (see Equation (1)).
Source: Authors' computations.

B) Equation (2): $C_{it} = y_{it}'\alpha_1 + \hat{\eta}_i'\alpha_2 + e_{it}$

Age 18

Independent Variables	*Men*		*Women*	
	Private Sector	*Public Sector*	*Private Sector*	*Public Sector*
Age	0.5544***	0.6166**	0.3326***	0.1013
Age^2	-1.2156***	-1.3736**	-0.7183***	-0.2158
Unemployment	-0.0067***	0.0025	-0.0002	0.0076***
$\hat{\eta}$	-0.0563***	0.0554***	-0.0268***	0.0363***
Nº of Observations	38,086	1,184	22,050	1,805
R-squared	0.051	0.199	0.31	0.327

Note: * significant at 10%, ** significant at 5%, *** significant at 1. Age is measured in months. Age^2 is divided by 100. $\hat{\eta}$ are the individual effects computed in the contribution status equations for age 19 and above.

Source: Authors' computations.

Table 3: Goodness of fit

	Percentage of Correct Predictions for...	
	$\tilde{C}_{it} = 0$	$\tilde{C}_{it} = 1$
Men private sector	90.9	93.9
Men public sector	93.2	98.9
Women private sector	94.6	95.4
Women public sector	92.4	98.6

Source: Authors' computations.

Table 4: Pre- social security lifetime formal labor income and social security wealth (in thousands of 2010 US dollars)

		mean	sd	p1	p50	p99
Men Private	Life time income	152.95	303.09	2.19	81.63	1271.99
	SSW	-3.97	14.54	-77.92	-0.94	12.88
	SSW/income	0.04	0.19	-0.12	-0.02	0.71
Men Public	Life time income	363.98	326.38	6.46	278.04	1597.50
	SSW	-17.98	23.44	-86.29	-7.01	9.32
	SSW/income	-0.03	0.06	-0.08	-0.03	0.18
Women Private	Life time income	109.39	319.04	0.51	54.01	764.57
	SSW	1.22	10.13	-46.14	0.56	19.09
	SSW/income	0.19	0.61	-0.14	0.02	2.65
Women Public	Life time income	291.51	237.82	6.25	239.50	1165.97
	SSW	-3.58	16.25	-66.45	1.47	15.90
	SSW/income	0.02	0.10	-0.06	0.01	0.43
TOTAL	Life time income	175.11	333.70	1.30	89.28	1211.41
	SSW	-3.62	15.71	-77.32	-0.23	17.06
	SSW/income	0.08	0.39	-0.13	-0.01	1.47

Source: Authors' computations.

Table 5: Gini coefficients of life time labor income before and after social security

		Gini before SS	Gini after SS
Men private	Estimate	0.588	0.571
	Lower bound (95%)	0.570	0.552
	Upper bound (95%)	0.607	0.590
Men public	Estimate	0.431	0.420
	Lower bound (95%)	0.422	0.411
	Upper bound (95%)	0.440	0.429
Women private	Estimate	0.625	0.595
	Lower bound (95%)	0.597	0.566
	Upper bound (95%)	0.652	0.624
Women public	Estimate	0.407	0.392
	Lower bound (95%)	0.399	0.383
	Upper bound (95%)	0.416	0.400
Total	Estimate	0.600	0.582
	Lower bound (95%)	0.589	0.570
	Upper bound (95%)	0.619	0.594

Source: Authors' computations.

Table 6: Indexes of redistribution

	Reynolds Smolensky	Standard Deviation
Men private	0.0175	0.0007
Men public	0.0109	0.0002
Women private	0.0310	0.0011
Women public	0.0158	0.0002
Total	0.0188	0.0004

Source: Authors' computations.

Table 7: Pre social security lifetime formal labor income and social security wealth under weak enforcement of pension eligibility conditions (in thousands of 2010 US dollars). a/

		mean	sd	p1	p50	p99
Men Private	Life time income	151.92	303.18	2.06	81.08	1266.49
	SSW	-3.73	15.40	-82.62	-0.49	9.02
	SSW/income	0.23	3.07	-0.09	-0.01	2.76
Men Public	Life time income	362.96	327.05	4.42	277.22	1597.50
	SSW	-18.49	24.05	-89.60	-7.51	8.05
	SSW/income	0.00	0.24	-0.09	-0.03	0.89
Women Private	Life time income	107.81	318.80	0.51	52.31	754.76
	SSW	2.25	10.34	-47.37	4.49	11.52
	SSW/income	0.64	2.77	-0.10	0.07	8.51
Women Public	Life time income	289.68	239.51	0.00	238.51	1165.97
	SSW	-4.05	16.57	-67.40	1.27	12.47
	SSW/income	0.10	0.94	-0.07	0.01	1.84
TOTAL	Life time income	173.76	333.83	0.76	87.76	1211.41
	SSW	-3.29	16.45	-80.09	0.77	11.07
	SSW/income	0.34	2.68	-0.09	0.01	5.05

/ In this scenario, we dropped the vesting period conditions to access pensions. See text for the details.

Source: Authors' computations

Table 8: Gini coefficients of life time labor income before and after social security under weak enforcement of pension eligibility conditions. a/

		Gini before SS	Gini after SS
Men private	Estimate	0.593	0.567
	Lower bound (95%)	0.575	0.548
	Upper bound (95%)	0.611	0.589
Men public	Estimate	0.434	0.422
	Lower bound (95%)	0.425	0.413
	Upper bound (95%)	0.443	0.431
Women private	Estimate	0.632	0.583
	Lower bound (95%)	0.605	0.553
	Upper bound (95%)	0.659	0.613
Women public	Estimate	0.414	0.398
	Lower bound (95%)	0.406	0.390
	Upper bound (95%)	0.423	0.407
Total	Estimate	0.606	0.580
	Lower bound (95%)	0.594	0.568
	Upper bound (95%)	0.617	0.592

Source: Authors' computations.

Table 9: Indexes of redistribution under weak enforcement of pension eligibility conditions a/

	Reynolds Smolensky	Standard Deviation
Men private	0.0258	0.0008
Men public	0.0117	0.0002
Women private	0.0491	0.0018
Women public	0.0160	0.0002
Total	0.0263	0.0006

Source: Authors' computations.

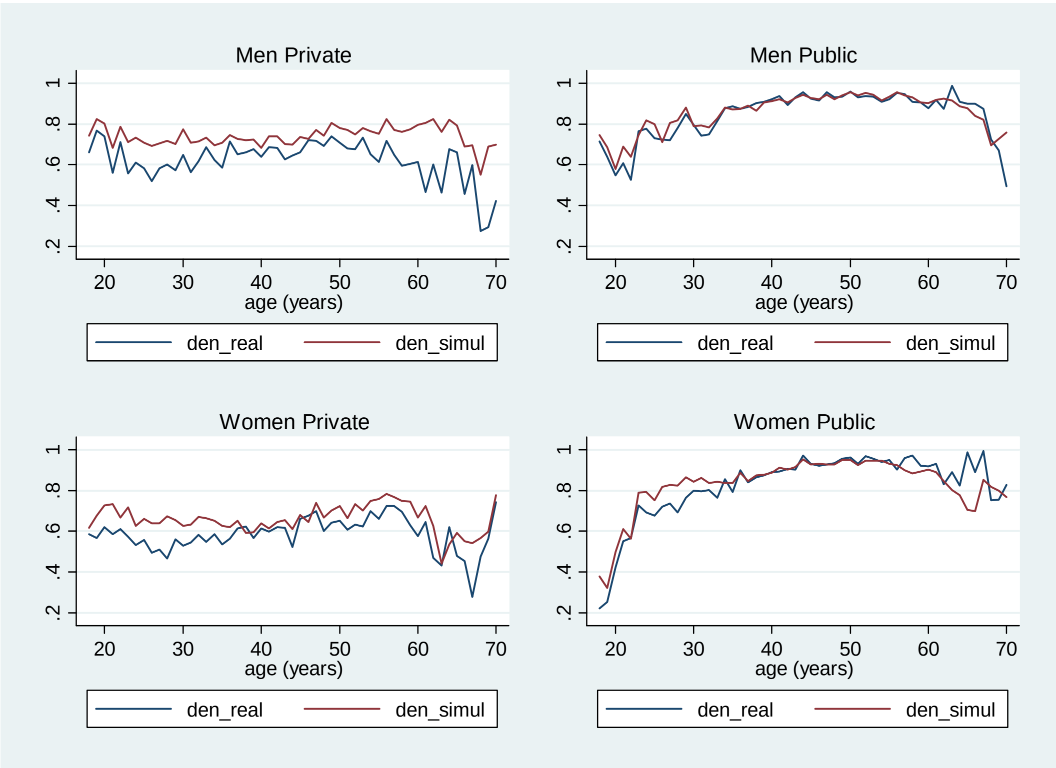
Table 10: Gini and Reynolds-Smolensky indexes when non-contributory pensions are included in the simulation

	Gini before SS	Gini after SS	Reynolds Smolensky
Men private	0.590	0.561	0.029
Men public	0.433	0.420	0.013
Women private	0.627	0.568	0.060
Women public	0.413	0.394	0.019
Total	0.603	0.572	0.031

Source: Authors' computations.

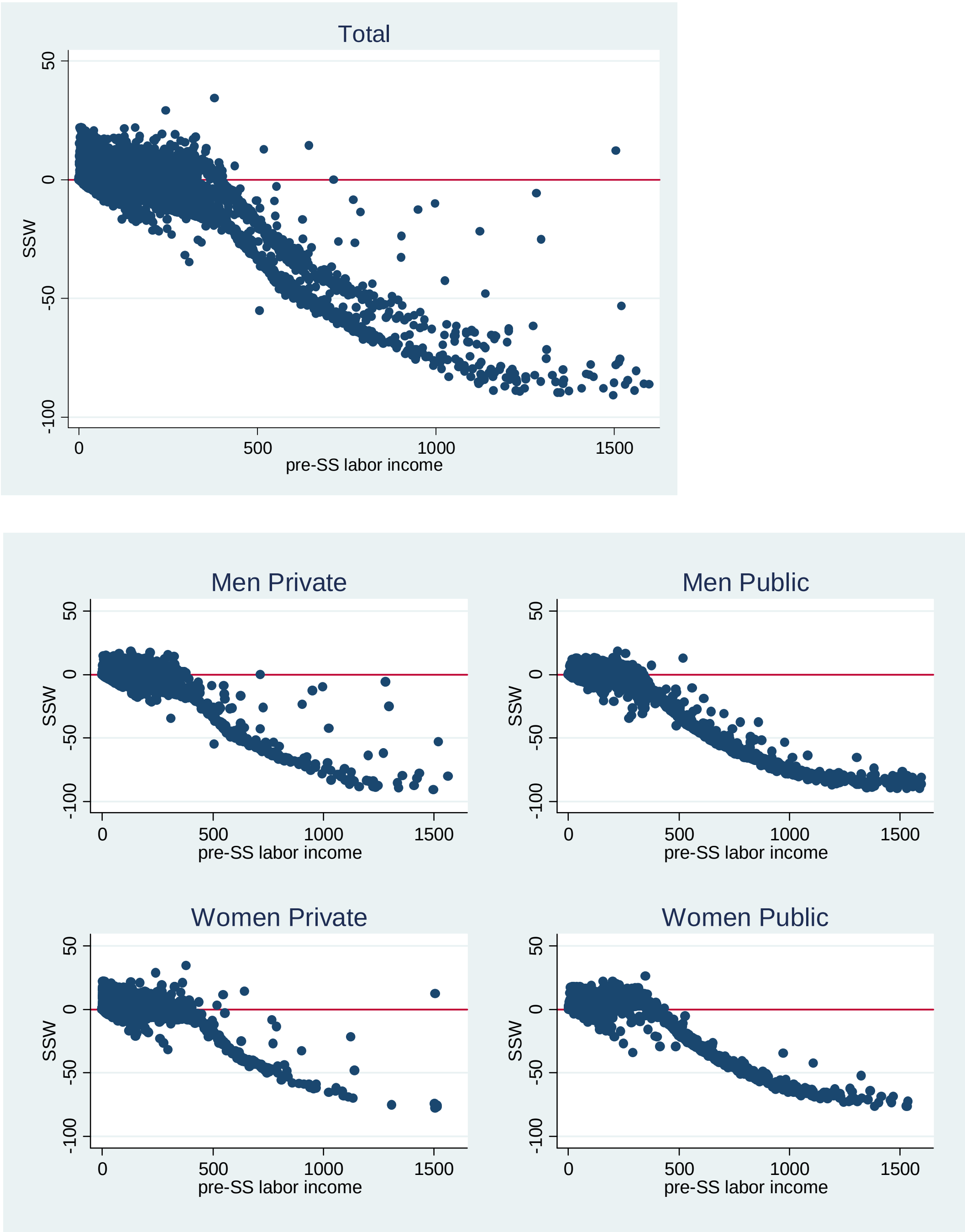
Figures

Figure 1: Observed and Simulated Contribution Densities by Age



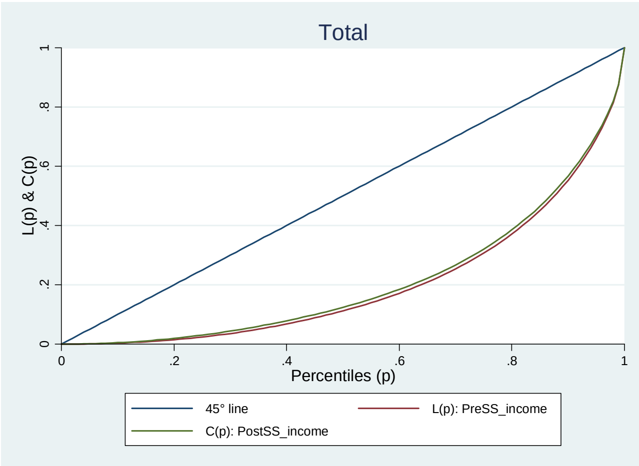
Source: Authors' computations.

Figure 2: Social security wealth and life time labor income (thousands of USD of Jan 2010)

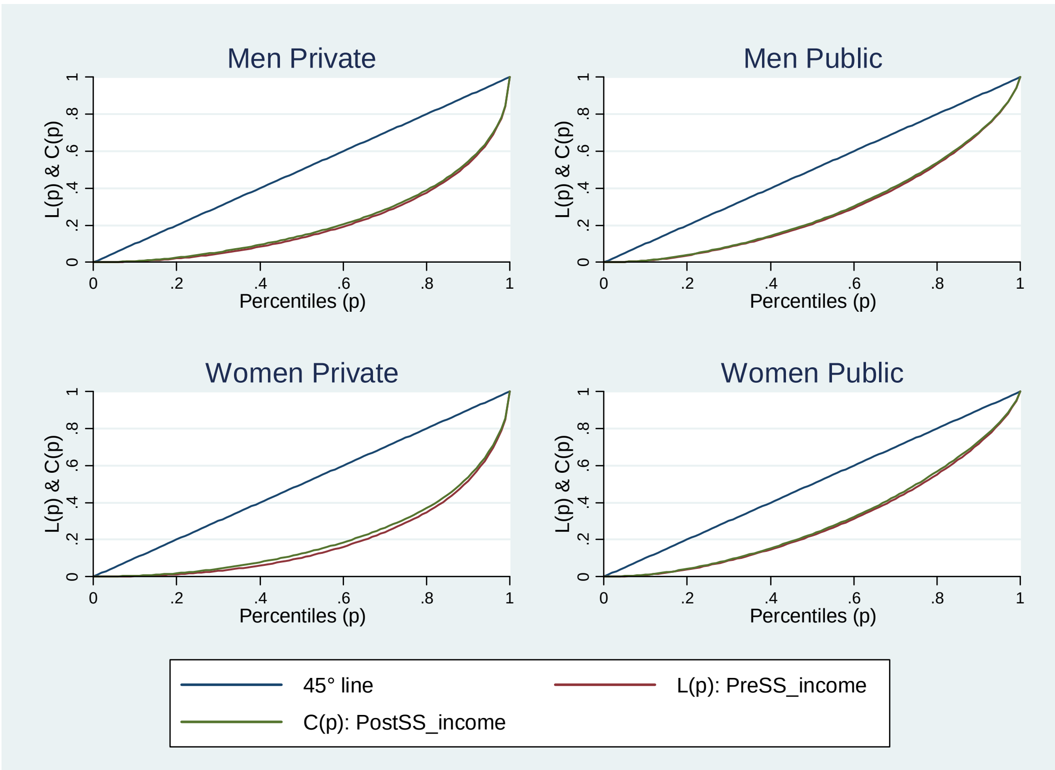


Source: Authors' computations.

Figure 3: Pre Social Security lifetime formal income Lorenz curve and post Social Security lifetime formal income concentration curve

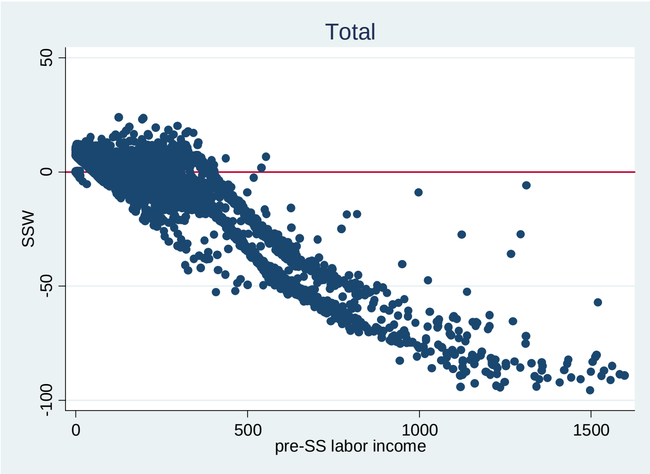


Source: Authors' computations.

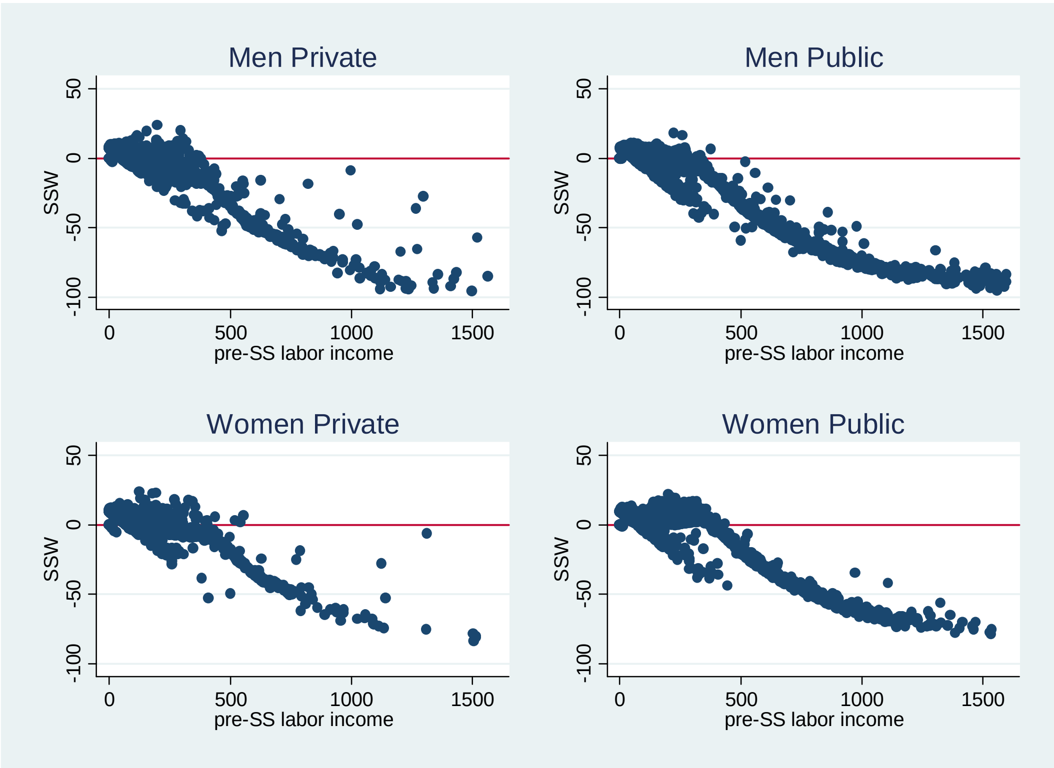


Source: Authors' computations.

Figure 4: Social security wealth and life time income under weak enforcement of pension eligibility conditions (thousands of USD of Jan 2010) a/

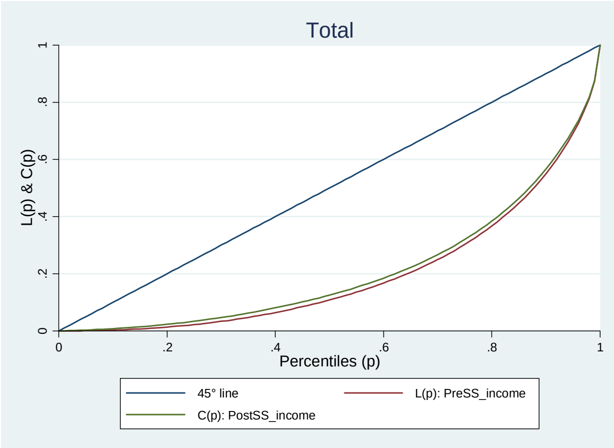


Source: Authors' computations.

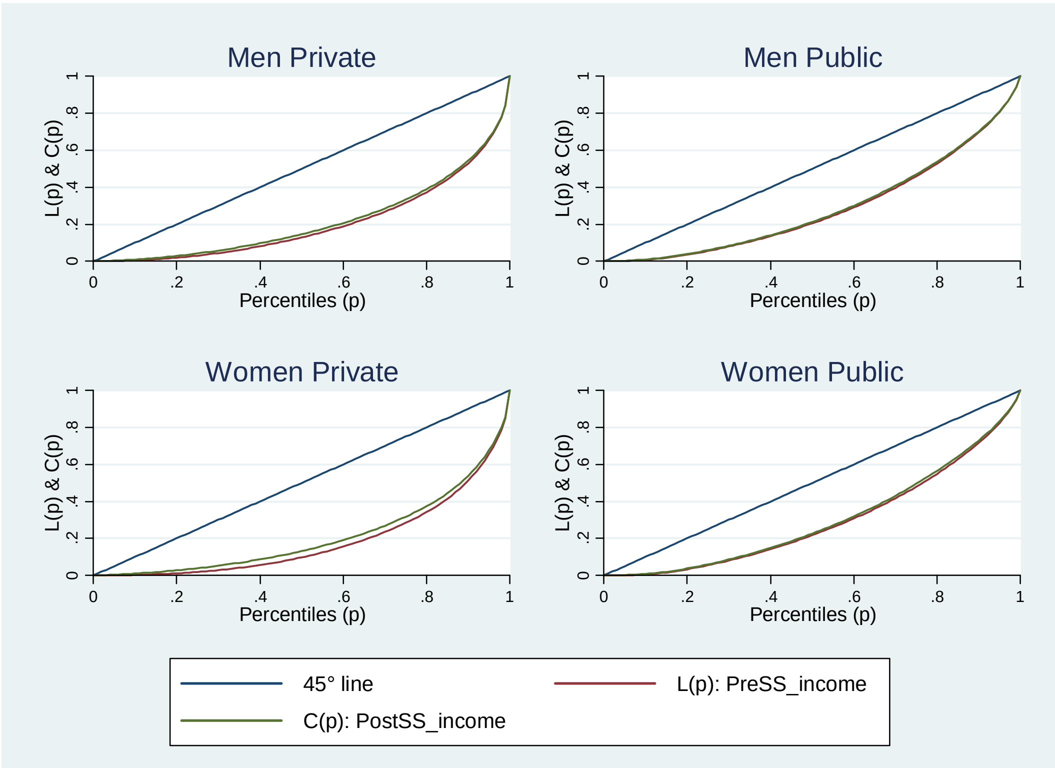


Source: Authors' computations.

Figure 5: Pre Social Security lifetime formal income Lorenz curve and post Social Security lifetime formal income concentration curve under weak enforcement of pension eligibility conditions



Source: Authors' computations.



Source: Authors' computations.