Assessing Fiscal Costs and the Distribution of Pensions in Transitions to FDC and NDC Systems: A Retrospective Analysis for Chile

Eduardo Fajnzylber and David A.Robalino

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Countries assessing structural pension reforms to address problems of financial sustainability and improve economic incentives face the choice between moving to a financial defined contribution (FDC) system, or to a notional defined contribution (NDC) system (or one of its variants). Unfortunately, comparisons regarding the performance of the two systems in terms of the pensions provided and transition costs are normally based on prospective actuarial estimations. In this paper, we follow a retrospective approach by simulating what would have happened in Chile if instead of the original FDC system introduced in 1981, the country would have implemented an NDC scheme. We find that transition costs under an FDC system can be considerably higher than under an NDC. In the case of Chile, other things being equal, introducing an NDC system would have generated fiscal savings during the first 45 years after the reform equivalent to 50% of initial GDP. The cost of the minimum pension guarantee would have been higher under an NDC system that pays the growth rate of the covered wage bill. This is because during the first twenty years after the reform the rate of return on financial assets was higher than the growth rate of wages. Our analysis suggests, however, that this does not have to be always the case. Depending on the assumptions regarding the stochastic process driving the dynamics of the rate of return paid by the FDC system, expected replacement rates under the NDC are not necessarily lower.

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1 Eduardo Fajnzylber is Assistant Professor, School of Government, Universidad Adolfo Ibáñez, Chile. The article was prepared while Mr. Fajnzylber was Head of the Research Department at the Chilean Pension Supervising Authority. David Robalino is Lead Economist in the Human Development Department of the World Bank and Co-Director of the Employment and Development Program at IZA.

Introduction

During the last decade, Notional Defined Contribution (NDC) systems have been introduced as a promising alternative to address the problems related to financial insolvency, non-transparent redistribution and weak incentives that pervade traditional defined benefit (DB) pay-as-you-go (PAYG) pension systems. NDCs remain financed on a PAYG basis but the benefit formula is modified to establish a transparent and actuarially fair link between contributions and benefits. If well designed, the system can be solvent at all times and will not accumulate unfunded liabilities that are common in DB schemes. Thus, the main difference between NDC and Financial Defined Contribution (FDC) systems is that, in the latter, the contributions from active workers are invested in financial instruments while in the former, contributions are used to pay for current pensions. As a result, in an FDC system contributions earn the rate of return on investments in financial assets, while in the “pure” NDC system the rate of return is equal to the growth rate of the PAYG asset – the present value of future contributions net of the value of pension rights accruing from those contributions (see Robalino and Bodor 2006). Because the growth rate of the PAYG asset is not readily observable, several proxies are used in practice.

One of the benefits of an NDC scheme is that it can facilitate the financing of the implicit pension debt of the “old” system and thus reduce the need for increasing taxes or reducing expenditures over the short-term. This is because the system remains PAYG and therefore new contributions can be used to finance current pensions (see Holzmann and Palmer 2006). In a transition to a FDC scheme, new contributions go to the financial market while the system needs to keep paying pensions to retirees from the previous system and acknowledging past contributions of workers who switched to the new one. These two effects could generate a significant short term fiscal pressure, known as a transition cost. In addition In essence, the government can continue to borrow contributions to finance the liabilities of the old system through the PAYG assets. What remains to be financed under an NDC reform are the inherited commitments above the old contribution rate and the reform-induced uncovered commitments due to the move to a lower contribution rate (Holzmann and Jousten, Chapter 18, this volume). On the down side, in a dynamically efficient economy, the growth rate of the PAYG asset (or proxies) is expected to be below the rate of return on financial assets. The

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2 For a discussion of “contribution asset” versus “pay-as-you-go asset” versus “hidden asset” – the differences and under what condition they coincide, see Baoda-Penas and Vidal-Maelia, chapter 23 in this volume, and Vidal-Maelia and Baoda-Penas (2010).

3 This transition cost appears to the extent that contributions are redirected from the PAYG to the FDC scheme. If the FDC scheme is introduced on top of the previous one (without changing the contribution rate to the DB scheme), there is no transition cost associated.
empirical evidence on the issue is mixed (see Holzmann and Hinz, 2005) but it could be that an NDC system, on average, pays a lower pension relative to the FDC system for the same contribution rate (presumably with less risk). This could involve higher fiscal costs as the expected value of minimum pension guarantees for the government increases. Understanding these tradeoffs between lower short-term and long-term transition costs is thus fundamental to guide policy choices regarding the implementation of one system over another or, more likely, the level of diversification of savings among the two.

To our knowledge, however, the fiscal tradeoffs involved in the implementation of FDCs and NDC systems have not undergone a rigorous assessment. The studies that exist (see for instance, World Bank 2004; World Bank 2006; World Bank forthcoming) are normally based on prospective actuarial estimations, which usually involve making non-trivial assumptions about the evolution of the most relevant parameters: GDP and wage growth, interest rates, coverage and contribution densities. At the same time, not enough attention has been given to the question of whether the rate of return of FDCs is consistently above the rate of return of NDCs and the tradeoffs in terms of pension risk.4

This paper sheds lights on these two questions. To address the limitation of prospective studies, we follow a retrospective approach by simulating what would have happened in Chile between 1981 and 2026, if instead of the FDC reform introduced in 1981, an NDC scheme would have been implemented. We use actual contribution histories from individuals who switched to the reformed system to compare the relative performance of the FDC and NDC schemes in terms of fiscal costs and the distribution of pensions and replacement rates, at the aggregate and individual level. Clearly, this approach is subject to the criticism that general equilibrium effects of an alternative reform are not taken into account. If an NDC had been introduced in 1981 individuals incentives and therefore labor supply and savings decisions may have been different. The accumulation of capital into individual accounts certainly had important macro-economic effects as well (see Holzmann, 1997, Klaus Schmidt-Hebbel, 2000). As a result, the dynamics of all prices (including interest rates and wages) may have been different. That stated, our paper is not attempting to estimate the welfare impact of an alternative reform. Our more modest goal is to inform policymakers about (i) the order of magnitude of the

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4 Dimson et al (2002) report that, for the period 1900-2000, the average real return on equity for 16 developed countries was 5.1%, whereas Maddison (2003) suggest that the equivalent growth rate of real GDP per capita was 2%. Risk considerations are taken into account in Dutta et al (2000), Matsen and Thøgersen (2004), De Menil et al (2006), which tend to suggest that the optimal combination of funded and unfunded systems is not on either of the two extremes. Knell (2008) incorporates the effect of preferences for relative consumption (with respect to a reference group), giving further support for including an unfunded component in the optimal pension mix.
potential fiscal savings from lower transition costs under NDCs; (ii) the difference in the level of pensions and replacement rates under both reforms and the potential extra costs related to the provision of minimum pension guarantees; and (iii) the level of plan members’ exposure to risks under the two systems.\(^5\)

The paper is organized in five sections. The next section briefly describes the main features of the 1981 Chilean reform and explains the assumptions made regarding the implementation of the hypothetical NDC system. It is followed by a description of the data and methods used to compare fiscal costs and the distribution of pensions both at the aggregate and individual level (Section 3). The main results from the analysis are discussed in Section 4 and Section 5 concludes.

I. The Original FDC Reform and the Hypothetical NDC Reform

In 1980, the Chilean government introduced a major reform to the pension systems, replacing the traditional PAYG arrangements by a unique national scheme, based on individual accounts, market capitalization and private management.\(^6\) The main motivation was to address problems of fragmentation and fiscal sustainability (see Annex 1).

Under the new system, all civilian dependent workers were required to contribute 10 percent of their covered income to the Pension Fund Administrator (PFA) of their choice, which charged an additional administration fee and an insurance premium for the Disability and Survivorship Insurance (DSI).\(^7\) PFAs are private firms created for the sole purpose of administering the benefits set by law, which include collecting contributions, managing individual accounts, investing the funds accumulated, taking out a DSI insurance policy, providing customer service and paying old-age, disability or survivorship benefits under a programmed withdrawal schedule or transferring the accumulated resources to a life insurance

\(^5\) In this article, we are concentrating on the risk originated in the variability of the rates of returns and how this affect the pension risk, which is captured by the variance of the distribution of replacement rates under both systems (and a series of alternative combinations of both). There are other sources of risk, which are not modeled here, some of which affect both schemes in a similar way (like economic risks, which affect the likelihood of making contributions) and some of which have differential impacts on both systems: under an FDC scheme, the government can influence, through regulation, the type of instruments eligible for the fund managers or could even choose to reverse the FDC reform; under an NDC scheme, the government could directly influence the notional rate of return and/or refuse to comply with promised benefits under conditions of fiscal stress.

\(^6\) The systems corresponding to the Armed Forces (Army, Navy, Air Force and Police) were not included in this reform and are still in place.

\(^7\) As of May 2011, the administrative fee is equivalent to approximately 1.49 percent of covered wages, and the DSI premium corresponds to an additional 1.49 percent, amounting to a total contribution rate equivalent to 12.98 percent of covered wages.
company if the beneficiary chooses to buy an annuity. Most of these requirements are strictly regulated by law and secondary regulations generated by the Superintendence of Pensions (SP, formerly known as the Superintendence of Pension Fund Administrators), the institution created in 1980 to regulate and supervise the PFAs. In particular, investment options are closely regulated by a complex structure of eligible instruments, quantitative limits and a (relative) minimum return requirement.\(^8\)

The key aspects of the FDC system are summarized below. For our hypothetical NDC system we keep as many of the original features as possible. The main differences are in terms of the calculation of the rate of return on contributions, the design of the payout phase and the role of the minimum pension guarantee.

1.1 Switching Options for Individuals Who Contributed to the Previous System

Under the 1980 reform, individuals who made contributions to one of the old PAYG systems were allowed to choose between staying in their regime or switching to the new one. Individuals who switched to the new system were not allowed to go back to their previous regime. Individuals who entered the labor market for the first time after the reform were automatically enrolled in the new system. For the hypothetical NDC reform, we will maintain these rules.

1.2 Contribution Rate

The contribution rate in the new system was significantly reduced, from rates around 23 percent in the case of the PAYG regimes,\(^9\) to approximately 14 percent (10 percent plus the administration fee charged by the AFPs, which averaged 4 percent for the average worker in the first 10 years). This difference could explain the massive switching that occurred in the initial years of the Chilean reform. To

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\(^8\) PFAs are currently allowed to invest the funds in fixed and variable income instruments, both in Chile and abroad. Starting in 2002, they have been required to offer at least four different funds (with an optional 5\(^{th}\) possibility), differentiated by the proportion of the assets that are allowed to be invested in variable income instruments (Multifunds). Some of the investment regulations were modified by the 2008 reform (see Rofman et al. 2008); only the main quantitative limits were left in the law, while the more detailed investment regime was left for secondary regulation.

\(^9\) In 1980, global contribution rates were 33.2 percent, 41.04 percent and 32.5 percent for the Social Security Service, EMPART and CANAEMPU, respectively (SAFP 2003). These rates included, however, benefits for old-age, sickness and industrial accidents, among others. Official contribution rates for pensions were lower (22.95 percent, 24.91 percent and 15.75 percent in the three previous cases) but not representative of the real financing needs, as resources were pooled to finance all types of benefits.
maintain consistency with the observed switching behaviour, we will assume a 10 percent contribution rate into the notional account for the base scenario of the hypothetical reform. Later in our analysis we will take into account differences in administrative costs between the two systems under alternative scenarios. The total contribution rate flowing to the NDC could be lower but our focus is only on the effective amount that is deposited in the individual accounts in the two systems.

1.3 Acknowledgment of Past Contributions

Past contributions from individuals who switched to the new system were generally acknowledged under the figure of a recognition bond, a promise made by the State to deposit a certain amount in the individual account, once he or she reached legal retirement age. The recognition bond was issued by request of the individual and earned a fixed 4 percent real interest rate from the moment the person joined the new system until legal retirement age.

For the hypothetical NDC reform a similar procedure would apply: A Notional Recognition Bond would be issued upon request of the affiliate, using the same formulas as current recognition bonds. The recognized balance would be automatically credited in the individual account at retirement age and would earn the same notional interest rate as current contributions from that moment on.10

1.4 Rate of Return on Contributions

Current contributions to the AFP system (not including the administrative fee) are saved in the individual’s account and automatically invested in a diversified portfolio of financial instruments. Balances are recalculated on a daily basis, adding contributions or withdrawals from the fund and the daily return of the pension fund chosen by the participant.

Under the hypothetical NDC reform, the procedure would be the same, except that the daily interest rate earned by the notional funds would be based, not on financial returns, but on a notional return calculated from the growth rate of wages or the growth rate of the wage bill of formal dependent workers.

10 An alternative procedure could have been to credit the recognized balance from the moment of calculation. In this case, the bond would earn the notional rate from the beginning, instead of the exogenous 4 percent rate.
1.5 Retirement Options

In general, individuals cannot retire until they reach the legal retirement age (60 years for women and 65 for men). When they decide to retire (which does not imply that they have to stop working), the accumulated balance in their account (including the recognition bond and potentially, the voluntary savings of the individual) can be returned to the participant in the form of a programmed withdrawal paid by an AFP or be used to purchase an annuity from a life insurance company.\(^{11}\) In the first case, the pension is recalculated every year based on current balance and age- and sex-specific life expectancy. In the case of death of the participant, the remaining balance can be transferred to legal beneficiaries or to the heirs of the deceased. The schedule of payment generally decreases over time and if the person lives long enough, the balance might be exhausted. In the second case, the entire balance is transferred to the insurance company, in exchange of a fixed real annuity until death of the pensioner and a survivorship annuity for legal beneficiaries. No heritage is paid in the absence of beneficiaries and survivorship benefits are a fixed fraction of the original pension, independent of the timing of the death. Individuals with low balances are not allowed to buy annuities and can only receive programmed withdrawals.

Under the hypothetical NDC reform, notional balances would always be transformed into a fixed annuity paid by the State, the amount of which would depend on the balance, age- but not sex-specific life expectancy of the participant and potential beneficiaries and a fixed interest rate corresponding to the average notional rate of the year prior to retirement. Similar to private annuities, survivorship benefits would be paid upon death but no heritage would be paid in absence of beneficiaries.

1.6 Poverty Prevention Programs

Until 2008, the government offered two publicly funded programs for individuals with low pensions or no pension at all: the minimum pension guarantee (MPG) and the assistance pensions (PASIS).\(^{12}\) Individuals who have contributed for at least 20 years (including the time recognized for

\(^{11}\) In the simulation part, we will assume that everybody chooses to annuitize, using the required gender-differentiated mortality tables.

\(^{12}\) This scheme was modified by the 2008 reform, which replaced the MPG and PASIS programs by a New Solidarity Pillar. The latter provides a basic solidarity pension for uncovered individuals in the 60 percent poorest part of the population and a solidarity complement for individuals in the same group with low pension rights (see Rofman et al. (2008) for more details on this program). In this article, we did not consider the new benefits introduced by this
participation in the old system) are entitled to an MPG, which is a fixed pension paid by the State when the individual balance is exhausted or when the annuity is below the minimum pension level. PASIS are paid to poor individuals over 65 who do not receive pensions or other forms of income.

The hypothetical NDC would include an MPG for individuals with calculated pensions below the minimum pension. A PASIS would not be required for affiliates of the system, as they would receive a lifetime annuity. We will estimate and project the fiscal costs of these provisions, associated to the population affiliated to the pension system. In other words, we will not attempt to estimate the cost of PASIS for the non-affiliated population, assuming that this cost would be the same under both the FDC and NDC regime.

reform as the MPG represents the most common form of protection introduced by countries that followed a Chilean style reform.
II. Data and Methods

Account balances can be constructed both for the new system and the hypothetical NDC scheme, using data from a representative sample of AFP affiliates for whom the entire (administrative) contribution history has been collected by the Superintendence of Pensions (SP).

The Affiliates Pension Histories (HPA, by its Spanish acronym) include basic demographic information (gender and date of birth) as well as monthly detail of all the contributions that were made, the fees that were charged, the pensions that were paid and the financial rates of returns earned from the investments made by the Pension Fund Administrators (the AFPs, private firms charged with the responsibility of managing the individual accounts and investing the funds saved). It also includes information on the recognition bonds issued by the government, representing the accrued rights earned by workers who contributed to the PAYG system before switching to the new one.\(^{13}\)

The methodology has two parts: the estimation of pensions and fiscal burden under the current FDC system and the equivalent analysis under the hypothetical NDC regime. In both cases, the analysis would cover the 1981-2026 period.

In the first part, actual contribution histories (between 1981 and 2006) are completed for the 2007-2026 period using an imputation method similar to Berstein et al. (2006). For a given history of rates of return, pensions are calculated for the different cohorts of workers, assuming that all individuals retire at the minimum retirement age (60 for women, 65 for men) and use the balance in their accounts (including recognition bonds) to buy a fixed annuity from that point on (using actual mortality tables and a given interest rate).\(^{14}\) The transition cost generated by this reform has been estimated for the 1981-2010 period in a number of publications and this estimation is extended for the 2010-2026 period from the recognitions bonds information from the HPA individuals and aggregate data from active affiliates and pensioners from the closed PAYG system (operational deficit).\(^{15}\)

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\(^{13}\) More detail about this data set also can be found in Berstein et al. (2006).

\(^{14}\) We implicitly assume that individuals do not become disabled or die before retirement age. Survival and disability pensions, even if potentially important in terms of their cost, require a more complex treatment that is beyond the scope of this article, which looks to compare two systems rather than attaining a precise projection of the Chilean pension system. Furthermore, at least mortality should not play an important role as approximately 97% of men and 98% of women aged 20 will reach age 65 (based on demographic mortality tables by gender, age group and marital status, INE 2006).

\(^{15}\) We use fiscal expenditures estimations presented in ECLAC (2006), based on a publication by Arenas de Mesa et al. (2005).
In the second part, pensions and fiscal cost are estimated under the hypothetical NDC reform. The calculation of pensions follows a similar procedure to the first step, with the exception that contributions are credited to a notional account, where they earn a notional rate of return. Upon retirement, the notional balance is converted into a fixed annuity. The key element in this estimation is the calculation procedure for the notional interest rate. In this application we limit ourselves to the growth rate of the wage bill.\footnote{This is a commonly used proxy that may not, however, be fully sustainable in the long run. Poland, for instance, adopted this type of rule for the notional rate of return. In section 3, we perform sensitivity analysis for a range of alternative notional rates of return.}

2.1 The Affiliates Pension Histories Data Set and Projected Contribution Histories

The Affiliates Pension Histories (HPA) includes the complete contribution history (in the AFP system) for a sample of approximately 24 thousand individuals, representative of the stock of affiliates of the system in July 2002, from the moment they join the system until December 2006. In addition, the data set also includes information on the recognition bonds held by the sampled individuals. For our purposes, we concentrate on the 4869 individuals in the sample who would attain legal retirement age before 2026 (women who were born before 1966 and men who were born before 1961).\footnote{Under the AFP system, individuals can start withdrawing funds at any time after the legal retirement age or, if they have accumulated sufficient funds to finance a reasonable pension and a reasonable replacement rate, they can retire earlier. In practice, a large fraction of individuals retire at the legal retirement age. In this article, we will assume that all individuals retire at the legal retirement age. This simplifying assumption should not affect the main results in this article, as i) early retirement would affect in a similar way both the FDC and the NDC scheme (as pensions are actuarially calculated) and the relation between them should be maintained, and ii) the fiscal cost should not be affected as recognition bonds are paid at legal retirement age, only individuals with pensions well above the minimum pension are allowed to retire early and the actuarial calculation of pensions guarantees that early retirement does not increase the fiscal burden.}
The following figure shows the projected number of individuals who would retire each year (those who reach the legal retirement age).\footnote{The figure was constructed using the 24 thousand individuals included in the sample, using expansion factors that were constructed by the Chilean Pension Supervising Authority. It assumes that all individuals reach the legal retirement age and retire at that point. In practice, some of these individuals may have died prior to legal retirement age and some of them may have retired before or after legal retirement age.}
contributions). Specifically, we separately estimate the following equations using standard fixed effect procedures with a linear probability model.\(^{19}\)

\[
\text{Contributes}_{it} = \beta_0 + \beta_1 \text{Age}_{it} + \beta_2 \text{Age}_{it}^2 + \gamma_1 \text{Female}_{i} \cdot \text{Age}_{it} + \gamma_2 \text{Female}_{i} \cdot \text{Age}_{it}^2 + \gamma_3 \cdot + \gamma_n \cdot ,
\]

\[
\text{LogEarnings}_{it} = \gamma_0 + \gamma_1 \text{Age}_{it} + \gamma_2 \text{Age}_{it}^2 + \gamma_3 \text{Female}_{i} \cdot \text{Age}_{it} + \gamma_4 \text{Female}_{i} \cdot \text{Age}_{it}^2 + \gamma_5 \cdot + \gamma_n \cdot ,
\]

(1)

In these specifications, the dependent variables are \(\text{Contributes}_{it}\), which is a dummy variable equal to one if individual \(i\) makes a contribution in month \(t\), and \(\text{LogEarnings}_{it}\), which is the log of earnings of individual \(i\) in month \(t\). The independent variables are \(\text{Age}_{it}\) (in months), the interaction between \(\text{Female}_{i}\) (a dummy variable equal to 1 if person \(i\) is a woman) and \(\text{Age}_{it}\), the same interaction with \(\text{Age}_{it}\) squared and an individual level fixed effect.

**Figure 1: Projected Number of Individuals Retiring Each Year from the AFP System**

The results of the estimation are summarized in Annex 2. We use the estimators (including the individual fixed effects) to predict contribution probabilities and expected earnings by age and gender. Expected contributions are then obtained by multiplying, in each month, the predicted probability with the predicted covered wage (see Figure 2).

\(^{19}\) The choice of a linear model allows us to estimate the fixed effect for each individual and use it to predict their future contributions. This is particularly important as in this case, given the administrative nature of the data, we do not have measures of education or ability.
Figure 2: Predicted Expected Contribution by Age and Gender

Note: The expected contribution is calculated by multiplying the probability of contributing at a given age (for a given gender) times the conditional income if contributing. The figure presents the average expected contribution for the individuals in the sample. Predictions for each individual also include the individual fixed effect components.
Source: Authors’ calculations.

2.2 Monthly Rates of Return

Under both the FDC and NDC systems, balances are constructed as the sum of contributions made during the lifetime, increased by the returns earned over time. We have:

\[ \text{Balance}_i = \text{recognition Bond}_i + \sum_{\text{age}_{i=5}}^{\text{Legal retirement age}} \left( 10\% \cdot \text{Wage}_{i,t} \cdot \prod_{\text{age}_{t+1}}^{\text{Legal retirement age}} (1+r_s) \right) \]  

where \( r_s \) is the real rate of return.

The difference between the two systems is that under the FDC scheme, \( r_s \) corresponds to the financial return of the instruments in which the pension funds are invested; whereas in the NDC scheme, the notional return is set by the authority, according to a predetermined rule – usually a proxy for the PAYG asset.

In this paper, the rate of return that we use for the FDC scheme is the historic rate of return earned by the AFP system between 1981 and 2007. For the years after 2007, we assume a fixed rate of return, set

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\(^{20}\) This formula represents a slight simplification of the actual calculation, as in some periods AFPs were allowed to charge additional fees that were charged directly from the balance in the account. These charges were historically low, not all PFAs actually applied them and they were eliminated during the 2008 reform.
at a level of 4 percent per year.\textsuperscript{22} In the case of the NDC system, we use demographic data on the growth rate of the real wage bill (the number of covered dependent workers multiplied by their average wage).\textsuperscript{23} After 2007, we also assume a constant growth rate of the wage bill equivalent to 4 percent per year. The annualized value of these two rates is graphed in Figure 3.

\textbf{Figure 3: Annualized Real Rates of Return under the FDC and NDC Systems}

![Graph showing annualized real rates of return under the FDC and NDC systems]

Source: Based on historic returns of the AFP system and labor data from the INE.

2.3 Pension Calculation

To calculate pensions under both schemes, we make use of actuarial formulas currently used under the AFP scheme. For simplicity, we assume that all individuals are single and they use their current balances to buy a fixed annuity. In this case, pensions can be obtained using the following formula:

\begin{align*}
\text{Pension} &= \text{Current Balance} \times \text{Annuity Factor}
\end{align*}

\textsuperscript{21} In every period the rate of return is constructed as the monthly weighted average return of the system, where the weights are given by the funds administered by each AFP and each type of Fund (after 2002, each AFP started offering five different funds).

\textsuperscript{22} The historic annual rate of return for the system, between 1981 and 2007, was 10.1 percent. During the same period, the real wage bill experienced an average 4.9 percent growth rate per year. Both employment and wage data were obtained from the National Statistical Agency (\textit{Instituto Nacional de Estadísticas} (INE)).

\textsuperscript{23} By assuming the same rate of return for the FDC and NDC schemes in non-observed periods, we avoid the results being drawn by explicit differences in return assumptions. In section 3, as a sensitivity analysis, we make alternative assumptions on the notional rate of return.
Annual Pension = \frac{Balance_t}{Unitary Necessary Capital_t} = \frac{Balance_t}{\sum_{s=0}^{10} \frac{Pr(Alive at age s \mid Alive at age t)}{(1 + R)^s}}

where the probabilities are obtained from gender-specific dynamic mortality tables and R represents the discount rate used by insurance companies to estimate the rate of return earned by the funds during the payment period for the annuity.

In the case of the FDC system, R is obtained from market data as the average implicit rate of return on all annuities sold during the previous six months. In periods where no market data is available for the implicit rate on annuities (before 1989 and after 2007), a fixed 3.5 percent is assumed. For simplicity, we use the same rates to calculate pensions from the NDC scheme. These rates are presented in Figure 4.

Figure 4: Discount Rates for Annuity Calculations (6-Month Average)

Since pensions are calculated for all individuals in the sample, it is possible to construct different statistics of the distribution of pensions over time (e.g., the average, the median, different quintiles of the distribution, and average pensions per quintile).

2.4 Fiscal Cost Calculations

One potential difference between the FDC and the counterfactual NDC scheme is the cost associated with annuity intermediation. These commissions reached a maximum at the end of 1999, representing 6% of balances (Reyes and Steward, 2008). Since then, additional regulations have reduced drastically, with an effective maximum of 2.5%. Under an NDC scheme, annuities are implicitly provided by the State, arguably at a lower intermediation cost. These differences are implicitly captured in the sensitivity analysis where alternative rates for the NDC scheme are used, to capture differences in administration costs.
The fiscal burden associated with the civil pension system can be decomposed into four components:25 (1) the operational deficit from the PAYG system managed by the Instituto de Normalización Previsional (INP), the agency in charge of administering the previous PAYG regimes: the difference between pensions paid to individuals who stayed in the old system and contributions from active workers affiliated with that system; (2) the cost of recognition bonds to individuals who switched to the new system; (3) the cost of minimum pension guarantees (MPG) to retirees with pensions below a guaranteed level who have at least 20 years of contributions; and (4) the cost of financing assistance pensions (PASIS) to a fraction of retirees (those in the poorest quintile of the earnings distribution) who did not participate in the formal schemes or exhausted their funds and do not have the 20 years of contributions required for the MPG.

Projections for the first three components are presented in the next section. The first two come directly from the individual pension projections under both systems. Minimum pension guarantees, on the other hand, are calculated for each individual when the contributory pension is below the minimum and the individual has contributed for at least 20 years. As discussed before, the State finances the difference between the pension and the guaranteed minimum.26 The costs of the minimum pension is thus projected at the individual level for every year after retirement, taking into account age*gender-specific survival probabilities. We did not project expenditures in the fourth component (assistance pensions), however, assuming that all retirees receive an annuity until death. Also, performing an accurate estimation of non-affiliated individuals is beyond the scope of this article.

It is important to note that the present value of the accumulated deficits in the old system and the value of the recognition bonds is exactly the same under both schemes. The differences we care about are in terms of the present value of the minimum pension guarantee and, more importantly, cash-flows. Under the NDC, government transfers to pay pensions in the old-system are lower since excess contributions are used to pay these pensions. Repayments of recognition bonds could also be initially lower because, contrary to the FDC system, in the case of the NDC the government would not need to transfer the total value of the bond to an AFP when the individual retire -- only what is needed to cover

25 The fiscal burden stemming from the Armed Forces pension schemes (which were not reformed in 1980) will not be included in this study, as it should be the same regardless of the reformed system. It is important to mention that these projections do not necessarily apply to the system currently in place, as this was reformed during 2008, replacing the MPG and assistance pension programs with a New Solidarity Pillar. This was not included in this article. Under no circumstance should these estimates be considered official projections.

26 The guaranteed levels are currently set at USD 209 for individuals between 65 and 70 years old, USD 228 for individuals between 70 and 75, and USD 244 for qualifying workers over 75.
any deficit that may appear between pensions in payment and contributions.\footnote{A deficit has to appear eventually, unless the rate of return in the NDC is set “low enough.” But in the case plan members would be implicitly taxed to cover the liabilities of the old system.} In our analysis, however, for transparency, we will assume that cash-flows related to the repayment of recognition bonds in the NDC are the same as in the FDC.

2.5 Estimating the Distribution of Benefits at the Individual Level and the Per Capita Cost of Guarantees

So far we have discussed the assessment of the fiscal costs and the distribution of pensions under the FDC and NDC systems from a prospective approach. These calculations, however, reflect one particular realization of the stochastic process driving the evolution of the interest rate and wages. We are interested in characterizing the distribution of pensions (at the individual level) under the FDC and NDC system. In other words, for individuals entering the pension system today, what would be the expected value of their pensions at retirement if the system was FDC or if the system was NDC.

Clearly, several factors determine the dynamics of interest rates and wages, from changing conditions in financial and labor markets to technological progress and foreign direct investment. Trying to capture these, however, would be a futile exercise. Instead, we focus on approximating the statistical process that best replicates current dynamics. We do this by using a very general time-series model where the value of the interest rate (or wages) at time $t$ is a function of past values and past and current random shocks (an autoregressive moving average -- ARMA -- process). In addition, we allow the variance of the random shocks to move over time as a function of past shocks and past variances (generalized autoregressive conditional heteroskedasticity in the error term -- GARCH). These models are commonly used in the study of the dynamics of asset prices. The ARMA component implies that there can be sequences of growing prices alternating with sequences of falling prices. The GARCH part implies that periods of high volatility in prices can be followed by periods of low volatility. The random shocks that generate these changes in regime can be the result of policies or changes in “animal spirits.” For the purpose of our analysis we do not need to know. We simply seek the model structure (i.e., the set of model parameters) that best replicates the data.

In its general form, the model can be described by the following equation:

\begin{equation}
\end{equation}
where and , the variance, evolves over time according to:

\[(5)\]

Combined with model (1), which gives the probabilities of contributing and the conditional covered earnings for a given age and gender, model (4-5) can be used to simulate forward career histories for individuals at different levels of income. Using Monte Carlo simulations it is then possible to derive both the distribution of pensions (replacement rates) at retirement and the distribution of expected fiscal costs related to the financing of the minimum pension guarantee.

III. Results

3.1 Pension Comparisons

We first take a look at the complete distribution of pensions under both schemes. Figure 5 presents the scatter plot between pensions under the FDC and NDC regimes (including the 45 percent degree line). Clearly, the systematically higher historic returns under the FDC scheme imply higher pensions for all individuals (24 percent higher on average). We then look at the level of coverage obtained by the system under the two alternative reforms, measured by the fraction of individuals that are able to self-finance a pension at least equivalent to the guaranteed minimum pension, the fraction of individuals that are not able to finance this amount but who are covered by the MPG and the proportion of retirees who neither finance a minimum pension nor are covered by the MPG program (see Figure 6).

\[\text{Figure 5: Distribution of Monthly Pension under FDC ad NDC Reforms} \]
\[\text{Given Past Rates of Return}\]

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28 In calculations, we used the minimum pension amount that was in effect in 2007, equivalent to approximately 25% of the average covered wage of participants in the system, as of December 2007.
Source: Authors’ calculations.
Overall, 51 percent of retirees will not be able to finance a minimum pension and would not be eligible for the MPG program under the FDC scheme. Under the NDC reform, the proportion would be only slightly higher (52 percent). The main difference arises between the other groups of individuals: Under the FDC reform, 39 percent of all retirees would be able to self-finance a minimum pension with the remaining 10 percent requiring the State MPG program to reach that level. Under the NDC reform, however, accumulated balances would be smaller and a larger fraction (14 percent) would require a top-up from the State.

To interpret these results, it is important to keep in mind that no behavioral changes were assumed, so that MPG eligibility (given by the number of contributions) would be the same in both cases. In other words, differences only originate in the different rates of returns of both systems and the resulting balances. In this case, notional returns for the past have been generally smaller than financial returns, therefore accumulated balances should also be smaller. Yet, this seems to mostly affect individuals that fulfilled the 20-year requirement, causing some of them to fall below the MP threshold.

To have a closer look at the effect on different parts of the income distribution, we calculated average pensions by quintile of the pension distribution, for both types of reform (see Figure 7). The main

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29 This result is similar to Berstein et al. (2006). This was one of the main elements of diagnostic presented to the Reform Committee created by President Bachelet in March 2006. Ultimately, the outcome was the introduction, in July 2008, of a New Solidarity Pillar that will cover all individuals above 65 years old in the bottom three quartiles. See Rofman et al. (2008) for a description of this reform and the diagnostic that led to it.
conclusion is that the stronger impact of the reform occurred in the higher range of the pension distribution, especially for the cohorts retiring in the intermediate periods (between 2006 and 2015). This phenomenon could be explained by the timing of the highest financial returns (which were strongly concentrated in the first 15 years, with a number of periods with rates over 20 percent) and the fact that we assumed, both for the FDC and NDC schemes, a constant 4% rate for contributions after 2007. In addition, low income workers have contribution densities that are shorter and more concentrated later in life, therefore are less “affected” by differences in the rates of return on contributions between the FDC and NDC systems.

Figure 7: Average Self-Financed Pensions by Quintiles under the FDC and NDC Reforms

Under FDC Reform

Under NDC Reform

Source: Authors’ calculations.

3.2 Fiscal Cost Comparisons

As discussed above, in our setting, differences in the fiscal impact of the two types of reform come from two elements: (i) differences in the cost of the MPG program originated in the higher past returns generated by the FDC regime; and (ii) differences in the value of government transfers to cover the deficit of the old-system, given that the initial fiscal surplus generated by the NDC regime can be used to cover this deficit (at least in part).

Regarding the first component, our prospective simulations show that the lower returns earned by contributions in the NDC scheme translate into higher MPG costs. Over the long-term, minimum pensions would cost 44 percent more under the NDC than the FDC reform (see ¡Error! No se encuentra el origen de la referencia.). The magnitude of the MPG cost under both reforms, however, is relatively
small compared to the other components of fiscal cost. As explained in the previous section, only a few individuals would be eligible for the State guarantee and the cost associated to these individuals is relatively low, as the State is only responsible for the difference between the self-financed pension and the guaranteed level. This difference tends to be small for individuals who fulfill the 20 years of contributions requirement. The magnitude of this effect could be different in other contexts, depending on the guaranteed level and eligibility requirements.

The second component of the fiscal difference between the two regimes comes from the fact that the NDC remains a PAYG scheme. The FDC reform makes most of the implicit pension debt (accrued to date liability) explicit in the form of operational deficit and recognition bonds. Under an NDC reform only part of implicit pension debt needs to be repaid – the liability of the old-system not covered financial and PAYG asset. But the NDC reform moves also to a new and lower contribution rate (10 percent instead of 23 percent), and the repayment of this share of the implicit pension debt needs also to be financed (see Holzmann and Jousen, Chapter 18, this volume). The new NDC scheme creates transitional surpluses that help finance the payment of operational deficit and recognition bonds but this surplus is not sufficient over the long-term – unless the NDC paid a rate of return on contributions below the sustainable level (an implicit tax). Eventually, the rest of NDC legacy costs needs to be budget financed as under an FDC reform. In our simulations we see that Figure 9 shows the annual contributions paid into the NDC scheme and the annual pensions paid to NDC participants, excluding the portion that is financed by the recognition bonds paid to the individuals who switched to the new system. During the first 45 years, the flow of contributions exceeds the flow of new obligations acquired by the NDC scheme – the Government borrows this surplus to finance part of the operational deficit of the INP. In the long run (and assuming that the selected wage growth is a good proxy for the sustainable notional interest rate), the surplus would disappear and no deficit should emerge (that is not covered by the repayments that the government needs to make to finance the unfunded liabilities of the old-scheme). It is important to notice that if the government only repaid recognition bonds when the NDC system generate a deficit, the surplus of the NDC system would be smaller (could be zero in some cases) but so would be the fiscal costs to the government.
Figure 8: Annual Fiscal Cost of Minimum Pension Guarantee under FDC and NDC Reforms (% GDP)

Source: Authors’ calculations.

Figure 9: Fiscal Surplus of the NDC Regime (% GDP)
To construct the evolution of total government expenditures on pensions, we also need the transition costs generated from the commitments made with individuals who had made contributions to the previous DB scheme. These commitments take the form of recognition bonds to be paid to individuals who switched to the new system (either the FDC or the NDC) and the operational deficit of the INP, originated in the difference between the contributions paid by workers who chose to stay in the previous scheme and pensions paid from this program.

Based on a publication by Arenas de Mesa et al. (2005), ECLAC (2006) presents projections until 2010 for the different components of the Chilean fiscal expenditures. As we are particularly interested in the level and timing of government transfers under both types of reform, we extended the projections on the transition costs for the entire period. To this end, we used current aggregate data on contributors and pensioners from the INP. Using recognition bonds data from the HPA sample, we also estimated the cost paid each year on this item during the projection horizon. The results from these projections are presented in Figure 10.

We see that, as a large number of participants switched early in the reform, the operational deficit of the old system increased rapidly at first, reflecting the drop in revenues from contributions. Then, as the number of pensions paid declines, the deficit of the old system falls over time. The cost associated with recognition bonds, on the other hand, picks up slowly. This is because these obligations are paid when individuals reach legal retirement age and only begin to decline as the number of active contributors that participated in the previous scheme diminishes.

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30 We used INP’s annual summary of pensioners (average pension) and contributors (average earnings) by age and gender. We assumed that current contributors keep participating in the system until they reach the legal retirement age, at which point they retire and start receiving 70 percent of their last income (with a floor set at today’s minimum pension) until they die. Using current mortality tables, pension expenditure is projected for current and future pensioners. The 70% replacement rate is the maximum replacement rate under the main programs, so these estimates should be considered as an upper bound on future operational deficits.
Finally, we are able to compute the total fiscal expenditure under both reforms. The net present value (for the first 45 years) of the fiscal cost under the FDC reform represents 133.7% of initial GDP, compared to the 78.1% under the NDC reform. As expected, there is a significant difference in the level and timing of the fiscal impacts of the FDC and NDC reforms. The NDC scheme implies lower fiscal pressures from the pension system during the entire 45-year window (the average difference is 1.24 percent of GDP between 1981 and 2025) but the difference is reduced over time (see Figure 11).

Table 1 presents the net present value (for the first 45 years) of the different components of fiscal expenditure under a number of different scenarios. Notice that in all scenarios, the transition cost components (INP operational deficit and recognition bonds) are kept constant. The first row corresponds to the FDC reform which implies the lower fiscal cost associated with the minimum pension guarantee (MPG) but also the highest fiscal cost in net present value. The reason is that the transition cost is paid entirely by the State during the first few years, whereas under the NDC scenarios, the surplus generated by the NDC scheme helps finance the initial transition cost.

The second scenario corresponds to the base NDC case described in the earlier sections, under which the notional interest rate corresponds to the growth rate of the wage base, usually lower than the

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31 The NPV calculations were done by simply adding up the annual deficit to GDP ratios. This is equivalent to the sum of discounted expenditures, using the GDP growth rates as discount rates, divided by the initial GDP. The magnitude using the same discount rate assumption is broadly in line with estimates based on Schmidt-Hebbel (1995) that arrive as 126 percent of GDP (see Holzmann, 1999).
financial interest rate borne by the FDC scheme. For this reason pensions are lower, implying a higher fraction of the population that qualifies for the MPG and thus a higher fiscal cost. The fact that workers keep contributing to the common pool, from which pensions are paid generates an important fiscal surplus during the whole period, equivalent to 56.2% of 1980 GDP. Overall, the NDC implies a 42% lower fiscal cost than the FDC reform.

Scenarios 1, 2 and 3 were constructed using a fixed annual notional rate, set at 1.5%, 3.0% and 4.5%, respectively. With the lower notional rate, NDC pensions are lower, which translates to a higher MPG cost but also a much higher NDC surplus. The fixed 4.5% interest rate provides very similar result to the NDC base scenario.

Scenario 4 is the same as the base NDC scenario but where we assume that, as operational costs are usually lower under a centralized PAYG scheme than under the FDC competitive system, the contribution rate could be set at 10.5% of covered wages, instead of the 10% that was actually used. This higher contribution rate translates to higher pensions, lower MPG cost and higher NDC surplus.

Finally, pensions under scenario 5 were calculated using unisex mortality tables, instead of the gender differentiated tables that are currently in use under the FDC program. This scenario was suggested by the experience of countries that have introduced NDC schemes, which tend to incorporate the use of unisex tables in pension calculations. As women tend to live longer than men, the use of unisex tables should increase women’ pensions and reduce men’s. The results suggest that this tends to increase the MPG fiscal cost (relative to the base scenario) but also increase the fiscal surplus by a higher fraction. The explanation behind these results is related to the fact that there are slightly more men than women in the sample (52.6% against 47.4%) and the unisex tables were constructed assuming a 50-50 split.

In summary, the NDC reform implies a significantly lower fiscal over a long period of time, which is only partially compensated by the increased cost of the MPG program. As explained earlier, this small MPG effect is due to the limited coverage of the program. Under a more generous scheme, like the New

---

32 It is interesting to note that under the FDC scheme, the equivalent of the NDC surplus corresponds to the rapid accumulation of assets owned by participants in the system, that are invested in financial instruments by the pension fund managers. As of December 2009, these funds were equivalent to 64% of 2009 GDP.

33 More precisely, pensions were calculated using the current tables for the correct sex of each individual in the sample and using the opposite sex. Both pensions were then averaged using the inverses of the alternative pensions: unisex pension = 1 / (0.5 / pension_man + 0.5 / pension_woman). This is equivalent to construct mortality tables averaging mortalities using a 50-50 proportion between men and women.
Solidarity Pillar that was introduced in Chile in 2008, the effect of lower pensions on the poverty prevention related costs could be significantly higher.

![Figure 11: Total Fiscal Expenditures under the FDC and NDC Reforms (% GDP)](image)

Source: Authors’ calculations.

**Table 1: Net Present Value of different components of fiscal expenditure under different scenarios (% of 1980 GDP)**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>INP operational deficit</th>
<th>Recognition Bonds</th>
<th>Minimum Pension Guarantee</th>
<th>NDC deficit (surplus)</th>
<th>Total fiscal expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDC reform</td>
<td>104.87%</td>
<td>27.73%</td>
<td>1.13%</td>
<td>0.00%</td>
<td>133.73%</td>
</tr>
<tr>
<td>NDC Base scenario</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notional rate = base wage growth</td>
<td>104.87%</td>
<td>27.73%</td>
<td>1.62%</td>
<td>-56.17%</td>
<td>78.06%</td>
</tr>
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<td>NDC Scenario 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notional rate = 1.5%</td>
<td>104.87%</td>
<td>27.73%</td>
<td>2.43%</td>
<td>-62.98%</td>
<td>72.06%</td>
</tr>
<tr>
<td>NDC Scenario 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notional rate = 3.0%</td>
<td>104.87%</td>
<td>27.73%</td>
<td>2.08%</td>
<td>-60.64%</td>
<td>74.05%</td>
</tr>
<tr>
<td>NDC Scenario 3</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notional rate = 4.5%</td>
<td>104.87%</td>
<td>27.73%</td>
<td>1.73%</td>
<td>-57.53%</td>
<td>76.81%</td>
</tr>
<tr>
<td>NDC scenario 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notional rate = base wage growth, 10.5% contribution rate</td>
<td>104.87%</td>
<td>27.73%</td>
<td>1.55%</td>
<td>-58.98%</td>
<td>75.18%</td>
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<tr>
<td>NDC scenario 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notional rate = base wage</td>
<td>104.87%</td>
<td>27.73%</td>
<td>1.70%</td>
<td>-56.86%</td>
<td>77.44%</td>
</tr>
</tbody>
</table>
growth, unisex mortality tables

Source: Authors’ calculations.

3.3 Expected Distribution of Pensions and Fiscal Costs at the Individual Level

As discussed above, the calculations in the previous section take into account a given realization of the stochastic process driving the dynamics of the rates of return in the two systems. In the past, rates of return on the FDC (i.e., rates of return on financial assets) have generally been above the rates of return of the NDC system (proxied in this paper by the growth rate of the covered wage bill). Our estimates of system (4-5), however, suggest that this does not have to always be the case. The best fit of the data for both rates of return (FDC and NDC schemes) involves setting i=0 and j=k=1 in equations (4) and (5) (see Appendix 3). Depending on the assumptions regarding \( m \) (the number of past values of the rates of return that influence current values) the FDC and NDC systems could pay similar rates of return on contributions (assuming that the sustainable rate of return for the NDC system is the wage bill).

When the rate of return on financial assets is assumed to evolve around a constant mean \( (m=0) \), which in the estimation converges to the mean observed between 1981 and 2006 or around 0.7 percent per month, the FDC system could pay very high returns on contributions. The annualized average rate of return is close to 9 percent per year, similar to the level observed during the last two decades. However, when the rate of return depends on its past realizations \( (m=3) \), which is a model that provides a better fit to the data, the mean converges to a lower level, which is closer to 5 percent real per year (see Figure 12).

Simulations of the rates of return on financial assets resulting from the two models are presented in Figure 13. Clearly, adopting one over the other has very important impacts on the distribution of pensions. With the high rate of return, for instance, the average replacement rate for the average worker would be equal or above 100 percent and for many individuals even higher (see right panel). The second model, on other hand, generates a more realistic distribution for the replacement rate that would average 50 percent (see left panel). In what follows, therefore, we work with the latter.
Using the estimated time-series models we look at the impact of FDCs and NDCs on: (i) the distribution of replacement rates at the individual level; and (ii) the distribution of the per capita fiscal costs of offering a minimum pension guarantee. In both cases we report the mean and the variance of the distribution. As a reference we also look at three other systems. Two are mixed systems where 70 and 40 percent of the contribution rate respectively is allocated to an FDC and the remainder to an NDC. The third is a pure NDC system that pays a constant 3 percent real annual rate of return on contributions.34

We work with an average worker and a low income worker belonging to the 25th percentile of the income distribution. Regarding the minimum pension we consider four scenarios: no minimum pension, a minimum pension indexed with inflation, a minimum pension growing at 1.5 percent real per year, and

34 This is an arbitrary reference considered to be a lower bond of the long-term growth rate of the economy.
a minimum pension growing at 2.5 percent real per year – which could be observed, for instance, if pensions were indexed by the growth rate of the average covered wage.

The results are presented in Table 1. The left side of the table refers the average worker whereas the right side refers to the low income worker. Horizontally the table has 4 blocks, one for each scenario regarding the minimum pension. Within each minimum pension scenario each row refers to one of the FDC/NDC combinations. Below we summarize the main results.

A first observation, which can be seen in the case of a pension system without a minimum pension guarantee, is that the differences in the rates of return paid by the two systems do not generate a large difference in the distribution of replacement rates. For the average worker the average replacement rate under the FDC system would be 61% whereas in the NDC system it would be 64% – and with a lower variance. In essence, over the medium term, the average rate of return on financial assets does not differ systematically from the growth rate of the covered wage bill. If the later is used as the notional interest rate, then the NDC system could offer similar pension benefits. Benefits would be considerably higher than those paid by a system where contributions are remunerated at a 3 percent real rate of return. For an average worker, for instance, this system would generate an average replacement rate of only 28%.35

We also observe that low income individuals would end up with very low replacement rates (close to 8 percent). This is mainly explained by shorter contribution densities. Hence, while model 1 predicts that the average worker would contribute around 50 percent of the time while active, workers in the 25th percentile would contribute less than 20 percent of the time.

As a result, the minimum pension guarantee plays an important role. However, contrary to what would have been observed to date (and particularly during the early times of the Chilean reform), the cost of financing this minimum pension does not have to be particularly higher under the NDC – unless the rate of return that the system can finance is in the order of 3 percent per year. This can be seen in the second panel of Table 1 where the minimum pension is supposed to be indexed with inflation. The average worker would not need access to the minimum pension. The large majority of low income workers, on the other hand, would and the average cost would be around USD 5,300 per capita, regardless of the combination between FDC and NDC.

35 Clearly, this assumes that the growth rate of the wage bill is a sustainable proxy, which often is not the case (see Robalino and Bodor 2006). A more robust proxy for the sustainable rate could be the growth rate of the average covered wage, which tends to be lower and would therefore generate lower pensions.
Clearly, if the minimum pension grows faster than inflation, more individuals, including average earners, would become eligible and costs would increase sharply. For instance, if the minimum pension grows at 2.5% real per year the cost of the guarantee for an average worker would be close to USD 15 thousand in the case of the FDC and 14 thousand in the case of the NDC. For the low income worker these costs would be USD 33 thousand.

Table 1: Impacts of Alternative Combinations of FDCs and NDCs on the Distribution of Replacement Rates and Fiscal Cost

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No Min Pension</td>
<td>100%</td>
<td>0.610</td>
<td>0.145</td>
<td>0.000</td>
<td>0.000</td>
<td>0.082</td>
<td>0.002</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>70%</td>
<td>0.627</td>
<td>0.084</td>
<td>0.000</td>
<td>0.000</td>
<td>0.085</td>
<td>0.004</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>40%</td>
<td>0.638</td>
<td>0.069</td>
<td>0.000</td>
<td>0.000</td>
<td>0.082</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0.640</td>
<td>0.048</td>
<td>0.000</td>
<td>0.000</td>
<td>0.084</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>NDC fix 3%</td>
<td></td>
<td>0.284</td>
<td>0.000</td>
<td>10.707</td>
<td>19.960</td>
<td>0.043</td>
<td>0.000</td>
<td>0.565</td>
</tr>
<tr>
<td>Min Pension 0%</td>
<td>100%</td>
<td>0.637</td>
<td>0.130</td>
<td>0.055</td>
<td>0.206</td>
<td>0.457</td>
<td>0.000</td>
<td>5.385</td>
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<td>70%</td>
<td>0.637</td>
<td>0.097</td>
<td>0.002</td>
<td>0.002</td>
<td>0.457</td>
<td>0.000</td>
<td>5.363</td>
</tr>
<tr>
<td></td>
<td>40%</td>
<td>0.635</td>
<td>0.045</td>
<td>0.000</td>
<td>0.000</td>
<td>0.457</td>
<td>0.000</td>
<td>5.384</td>
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<td></td>
<td>0%</td>
<td>0.638</td>
<td>0.054</td>
<td>0.002</td>
<td>0.002</td>
<td>0.457</td>
<td>0.000</td>
<td>5.379</td>
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<td>NDC fix 3%</td>
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<td>0.284</td>
<td>0.000</td>
<td>10.795</td>
<td>21.537</td>
<td>0.457</td>
<td>0.000</td>
<td>6.528</td>
</tr>
<tr>
<td>Min Pension 2.5%</td>
<td>70%</td>
<td>0.632</td>
<td>0.070</td>
<td>0.507</td>
<td>1.457</td>
<td>0.895</td>
<td>0.000</td>
<td>13.915</td>
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<tr>
<td></td>
<td>40%</td>
<td>0.632</td>
<td>0.040</td>
<td>0.308</td>
<td>0.834</td>
<td>0.895</td>
<td>0.000</td>
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<td></td>
<td>0%</td>
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<td>0.000</td>
<td>15.933</td>
<td>18.213</td>
<td>0.895</td>
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<td>70%</td>
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<td>0.128</td>
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<td>38.410</td>
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<td></td>
<td>40%</td>
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<td>0.074</td>
<td>13.228</td>
<td>32.374</td>
<td>1.736</td>
<td>0.000</td>
<td>33.408</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0.771</td>
<td>0.015</td>
<td>13.201</td>
<td>31.614</td>
<td>1.736</td>
<td>0.000</td>
<td>33.404</td>
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<td></td>
<td>0.725</td>
<td>0.000</td>
<td>35.387</td>
<td>15.955</td>
<td>1.736</td>
<td>0.000</td>
<td>34.564</td>
</tr>
</tbody>
</table>

Note: \(E(\cdot)\) and \(V(\cdot)\) give respectively the mean and variance of the distributions. “RR” is the replacement rate (the pension at retirement divided by the last salary). “Cost” refers to fiscal costs expressed in Thousand USD per capita.

Source: Authors’ calculations.
IV. Concluding Remarks

In this paper we have analyzed the relative impacts that the introduction of FDCs and NDCs can have on fiscal expenditures and the distribution of pensions using Chile as the reference country. The methodological innovation in the analysis is the use of long term retrospective simulations that look at what would have happened in Chile if instead of the original FDC system introduced in 1981, the country would have implemented an NDC system. This offers a large advantage over prospective simulations that strongly depend on non-trivial assumptions about the evolution of the most relevant parameters (GDP and wage growth, interest rates, coverage and contribution densities). Thus, we use actual contribution histories from individuals who switched to the FDC system and monthly time series on rates of return on savings and the growth rate of the wage bill to compare the fiscal impact of the reforms and the distribution of pensions and replacement rates at the aggregate and individual level.

The main finding is that transition costs under an FDC system are considerably higher than under an NDC system. In the case of Chile, other things being equal, introducing an NDC systems in 1981 instead of and FDC would have generated fiscal savings during the first 45 years after the reform equivalent to 50% of initial GDP. These fiscal costs of an hypothetical NDC reform are not linked to the NDC design per se but specific to Chile: (i) The inherited costs due to financial unsustainability of the old scheme (under the old 23 percent contribution rate) – they would have to be paid in any case; and (ii) the reform induced legacy costs through the move toward much lower contribution rate of 10 percent.

The lower fiscal costs of an NDC reform are the result of the continued pay-as-you go character of the scheme in which liabilities can be matched with PAYG assets. As a result, under an NDC (or a sustainable NDB system), a sustainable implicit debt needs never to be repaid as it can be rolled over from generation to generation. But if the rate of return of an FDC scheme is, on average, above the rate of an NDC scheme, there is an implicit tax under the latter that individuals pay throughout their lifetime. Savings could have been even larger if under the NDC systems the government did not pay in full the recognition bonds when individuals retire. Clearly, if the NDC pays a “fair” rate of return on contributions, this borrowing cannot continue forever. The unfunded liabilities of the old system do not disappear in the case of an NDC reform and would need to be repaid eventually, at least in part, through general revenues. But an NDC system can allow governments to better spread costs over time.

One of the potential tradeoffs of introducing an NDC system (i.e., pay-as-you-go system) is that, in theory, the sustainable rate of return on contributions is expected to be lower -- at least over the long-
run. And, in fact, in the case of Chile, rates of return under the FDC system were much higher during the first 20 years of the reform. As a result, pensions under the FDC system were higher than under the NDC system and thus the minimum pension guarantee cost less. As a result an NDC reform would have imposed an implicit tax on the contributors and tax payers. Our analysis suggests, however, that this does not have to be the case. Depending on the assumptions regarding the stochastic process driving the dynamics of the rate of return paid by the FDC system, expected replacement rates under the NDC are not necessarily lower and no implicit tax may emerge.

A few caveats are worth noting. The results presented in this paper are representative of the case of a middle-income country, with an intermediate degree of coverage of dependent workers, placed in the middle of its demographic transition. The transition cost of the FDC type of reform undertaken by Chile would be much larger in countries with a larger formal sector or an older population but smaller for young, informal low-income countries. In addition, the Chilean experience was effective in successfully introducing a market-based system, but the exhibited high financial returns were the result of a number of economic and financial market reforms, including privatization of public enterprises, capital markets reforms, the development of a housing mortgage market and infrastructure concession projects that provided a steady supply of long term investment vehicles. Finally, the tradeoffs presented here are not the only elements to be taken into consideration when planning a reform of this nature. Relying on financial capitalization can imply higher returns than notional schemes but with higher volatility. Administrative costs should also be considered, as centralized schemes can benefit from substantial economies of scale and are not subject to marketing or sales costs. On the other hand, public schemes are often subject to political pressures to increase benefits without the necessary compensation in terms of higher contribution rates. This compromises the financial sustainability of the system and exposes plan members to an additional source of uncertainty.

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36 See Holzmann and Hinz (2005) for a detailed discussion of pension reform options and enabling conditions.
References


Annex 1. Background to the Chilean Pension Reform

By 1980, Chile’s pension system was no different than many other countries that had based their social protection for old age on compulsory contributions by dependent workers to defined benefit PAYG schemes. After the original Social Security Service was created in 1924, a number of additional schemes were introduced to cover different types of workers, the main ones being the Private Employees’ Fund (EMPART) and the Public Employees and Journalists Fund (CANAEMPU). By 1979 there were 32 Social Security Institutions (Cajas de Previsión), giving rise to over a hundred different social security schemes, with considerable inequality between the benefits of the various institutions providing the service. There were different requirements for receiving a pension (in terms of age, years of service or sex), different contribution rates and different benefit structures.

37 For a detailed description of the old system, see SAFP (2003), chapter 2.
While originally created as Partial Capitalization Systems (reserve funds accumulated excess contributions during the early period), by the end of the 1970s, and despite contribution rates over 30 percent of covered wages, benefit payments largely exceeded contributions into the system and approximately 40 percent of the system’s income came from the State (3.11 percent of 1980 GDP). This strong financial imbalances originated in demographic, economic and administrative factors.

Due to demographic transition and generous provisions to pensioners, the ratio of number of contributors to pensioners went from 10.8 in 1960 to 2.2 in 1980. Despite substantial increases in real wages (128.9 percent between 1965 and 1972) and reductions in unemployment (from 5.4 to 3 percent), there were substantial increases in average pensions and in a number of other benefits (family allowance, sickness, industrial accidents, unemployment, etc.). After 1973, during the early years of the military regime, real wages dropped dramatically, unemployment rose, together with social security evasion and the lack of indexation mechanisms significantly eroded the real level of average pensions. Finally, accumulated reserves had been invested in public and private financial instruments (including loans to participants for a variety of purposes) without explicit inflation adjustments. These factors translated into a gradual reduction in the real value of reserves, reaching the end of the 1970s with a substantial financial imbalance.

After a number of measures were introduced between 1974 and 1979 to improve the fiscal situation, the new system was introduced in 1981.

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38 SAFP (2003).

39 The measures included a fiscal tightening program introduced in 1977, the introduction of uniform indexing rules for all pensions and uniform retirement ages (60 for women, 65 for men) for all schemes, independently of the number of years contributed (Diamond and Valdés 1993).
Annex 2: Result of the Estimation of the Fixed Effect Models

Contribution Equation

Fixed-effects (within) regression  Number of obs = 5715884
Group variable: rut  Number of groups = 24172

R-sq: within = 0.0394  Obs per group: min = 1
between = 0.0345  avg = 236.5
overall = 0.0276  max = 324

\[ F(4,5691708) = 58421.81 \]
\[ corr(u_i, Xb) = -0.4631 \]
\[ Prob > F = 0.0000 \]

| DV=contributes | Coefficient | Std. error | T-stat. | P>|t| | 95% Confidence interval |
|----------------|-------------|------------|---------|-------|-------------------------|
| Age in months  | 0.0041767   | 0.0000123  | 339.7200000 | 0.000 | 0.0041526 - 0.0042008  |
| Age^2          | -0.0000038  | 0.0000000 | -285.9300000 | 0.000 | -0.0000038 - 0.0000037 |
| Female         | -0.0020546  | 0.0000210  | -97.7000000 | 0.000 | -0.0020958 - 0.0020134 |
| Female*Age^2   | 0.0000223   | 0.0000000 | 96.6300000 | 0.000 | 0.0000222 - 0.0000023  |
| Constant       | -0.4343761  | 0.0022074  | -196.7800000 | 0.000 | -0.4387024 - 0.4300497 |

\[ \sigma_u = 0.34410044 \]
\[ \sigma_e = 0.38421923 \]
\[ \rho = 0.44508258 \]

F test that all \( u_i = 0 \):  \( F(24171, 5691708) = 143.42 \)  \( Prob > F = 0.0000 \)

Log(earnings) Equation

Fixed-effects (within) regression  Number of obs = 2439073
Group variable: rut  Number of groups = 23663

R-sq: within = 0.1431  Obs per group: min = 1
between = 0.0409  avg = 103.1
overall = 0.0472  max = 321

\[ F(4,2415406) = 100805.01 \]
\[ corr(u_i, Xb) = -0.4204 \]
\[ Prob > F = 0.0000 \]

| DV=contributes | Coefficient | Std. error | T-stat. | P>|t| | 95% Confidence interval |
|----------------|-------------|------------|---------|-------|-------------------------|
| Age in months  | 0.0092647   | 0.0000383  | 241.9100000 | 0.000 | 0.0091897 - 0.0093398 |
| Age^2          | -0.0000059  | 0.0000000 | -144.8600000 | 0.000 | -0.0000059 - 0.0000058 |
| Female         | -0.0026423  | 0.0000725  | -36.4700000 | 0.000 | -0.0027843 - 0.0025003 |
| Female*Age^2   | 0.0000034   | 0.0000001 | 43.3500000 | 0.000 | 0.0000032 - 0.0000035 |
| Constant       | -0.4084472  | 0.0074511  | -54.8200000 | 0.000 | -0.4230511 - 0.3938433 |

\[ \sigma_u = 0.83107918 \]
\[ \sigma_e = 0.655581 \]
\[ \rho = 0.61642616 \]

F test that all \( u_i = 0 \):  \( F(23662, 2415406) = 117.20 \)  \( Prob > F = 0.0000 \)
Annex 3: Results of the Estimation of the ARMA-GARCH Models

Model Growth Rate of Covered Wage Bill

Log likelihood = 858.4386  \hspace{1cm} \text{wald chi2(3)} = 49.62
\hspace{1cm} \text{Prob > chi2} = 0.0000

| OPG | Coef. | Std. Err. | z   | P>|z| | [95% Conf. Interval] |
|-----|-------|-----------|-----|------|---------------------|
| _xw | _cons | 0.004759  | 0.0013145 | 3.62 | 0.000 | 0.0021827 - 0.0073354 |
| ARMA | ma | .4208174 | .0646961 | 6.50 | 0.000 | .2940153 - .5476195 |
| | L1. | .3254827 | .0656815 | 4.96 | 0.000 | .1967494 - .4542161 |
| | L2. | .2065236 | .0687021 | 3.01 | 0.003 | .0718699 - .341772 |
| ARCH | arch | .0620752 | .0127976 | 4.85 | 0.000 | .0369923 - .0871581 |
| | L1. | .933307 | .0117302 | 79.56 | 0.000 | .9103163 - .9562978 |
| | _cons | 6.94e-07 | 8.56e-07 | 0.81 | 0.418 | -9.85e-07 - 2.37e-06 |

Model A for Rate of Return on Financial Assets

Log likelihood = 888.1482  \hspace{1cm} \text{wald chi2(3)} = 32.08
\hspace{1cm} \text{Prob > chi2} = 0.0000

| OPG | Coef. | Std. Err. | z   | P>|z| | [95% Conf. Interval] |
|-----|-------|-----------|-----|------|---------------------|
| _xi | _cons | 0.0072569 | 0.0010867 | 6.68 | 0.000 | 0.0051269 - 0.0093868 |
| ARMA | ma | .3651807 | .0647395 | 5.64 | 0.000 | .2382936 - .4920678 |
| | L1. | .1364818 | .065762 | 2.08 | 0.038 | .0075906 - .2653731 |
| | L2. | .0841355 | .0695468 | 1.21 | 0.226 | -.0521738 - .2204448 |
| ARCH | arch | .2190412 | .0605914 | 3.62 | 0.000 | .1002842 - .3377982 |
| | L1. | .7753848 | .0560713 | 13.83 | 0.000 | .6654871 - .8852825 |
| | _cons | 7.31e-06 | 4.18e-06 | 1.75 | 0.080 | -8.72e-07 - 0.000155 |

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Observed and Predicted Growth Rate of the Rate of Return on Financial Assets (x100)

Observed and Predicted Growth Rate of the Covered Wage Bill