© *The Journal of Risk and Insurance*, 2006, Vol. 73, No. 3, 489-515

Subjective Economic Risk to Beneficiaries in Notional Defined Contribution Accounts

Carlos Vidal-Meliá
Inmaculada Domínguez-Fabián
José Enrique Devesa-Carpio

Abstract

This article aims to quantify the *aggregate subjective economic* risk to which beneficiaries would be exposed if a retirement pension system based on notional account philosophy were introduced. We use scenario generation techniques to make projections of the factors that determine the real expected internal rate of return (IRR) and the expected replacement rate (RR) for the beneficiary according to six retirement formulae based on the most widely accepted rates or indices. We then apply the model to the case of Spain. Our projections are based on Herce and Alonso's macroeconomic scenario 2000–2050 (2000) and include information about the past performance of the indices and the time period the forecast is to cover. The results of the IRR calculation—average value, standard deviation, and value-at-risk (VaR)—are analyzed both in objective terms and for different degrees of participants' risk aversion.

Introduction

According to Hoskins (2003), we are indeed living in a "pension reform era," and there is no evidence that the pension reform debate is diminishing. On the contrary, it is only just beginning to heat up in certain parts of the world, for example the Caribbean, the Gulf States, and parts of Asia and Africa. The race to reform pension systems in

---

Carlos Vidal-Meliá and José Enrique Devesa-Carpio are at the Universidad de Valencia, Facultad de Economía, Departamento de Economía Financiera y Actuarial. Avenida de los Naranjos, s.n. 46022 Valencia, Spain. Inmaculada Domínguez-Fabián is at the Universidad de Extremadura, Facultad de Estudios Empresariales y Turismo, Departamento de Economía Financiera y Contabilidad, Avenida de la Universidad, s.n. 10071 Cáceres, Spain. The authors can be contacted via e-mail: carlos.vidal@uv.es, enrique.devesa@uv.es, and idomingu@guadiana.unex.es, respectively. The authors would like to thank Celi Aragón of the University of Valencia for her help in finding data, and María del Carmen Boada Penas, Pierre Devolder, Peter Hall, Ana Lejárraga-García, Julio Lucia-López, and Salvador Valdés-Prieto for their useful suggestions and comments. The comments and suggestions made by the journal's anonymous referees were especially helpful. A preliminary version of this article was presented at the XI Foro de Finanzas in Alicante, Spain. A previous version was published by FUNCAS (Fundación de Cajas de Ahorro Confederadas). Financial support from FUNCAS is gratefully acknowledged. Any errors are due entirely to the authors.

many countries over the last few years has been such that, as Valdés-Prieto (2002) points out, the problems of pension reform have begun to dominate economic policy. The main pension reforms[1] proposed and applied can be summarized as parametric reforms of the pay-as-you-go (PAYG) system, changes to other (mainly capitalization) systems, and systems combining capitalization and PAYG, as proposed chiefly by the World Bank. Reform trends championed by the main international organizations can be found in articles by Gillion (2000), Holzmann (2000), and Queisser (2000).

One of the most important recent innovations in public pension reform has been the introduction of so-called notional defined contribution accounts (NDCs) in some countries, namely Brazil[2] (1999), Italy (1995), Latvia (1996), Mongolia (2000), the Kyrgyz Republic (1997),[3] Poland (1999), and Sweden (1999). Other countries such as China, Russia, Austria, and the Czech Republic are also seriously thinking about introducing them. This type of retirement formulation is considered suitable for those countries where, due to special demographic or political conditions, it is difficult to introduce an at least partial accumulation of funds. The system establishes an analogy between the PAYG and capitalization systems by incorporating into the PAYG system actuarial and financial instruments used in the capitalization system. According to Valdés-Prieto (2000), this strengthens the long-term financial solvency of the PAYG system but increases the uncertainty surrounding the pension to be received by the beneficiary.[4]

This article will concern itself with estimating the *aggregate subjective economic* risk the beneficiary would be exposed to if a retirement pension system based on NDCs were to be introduced. We will not be measuring the political risk of NDCs, and although the demographic risk will not be analyzed directly either, it is taken into account implicitly when considering a number of indices used to calculate the formula for obtaining the retirement pension.

The estimated *aggregate subjective economic* risk to the beneficiary is applied to the case of Spain, though the model put forward is equally valid for any country. The European Union, the World Bank, and the OECD along with various researchers[5] have all strongly recommended an in-depth revision of the Spanish public pension system. All are agreed that, at least in the long term, the financial sustainability of the system is seriously at risk. One valid possibility could be the introduction of notional accounts, as suggested by Vidal-Meliá and Domínguez-Febián (2006) and Devesa-Carpio and Vidal-Meliá (2004). The latter have studied the effect that the introduction

[1] Information relating to the reforms carried out, by area or by country, can be found in papers by Boldrin et al. (1999), Börsch-Supan, Palacios, and Tumbarello (1999), Devesa-Carpio and Vidal-Meliá (2001), Fox and Palmer (2000, 2001), Holzmann (2006), Holzmann, MacKellar, and Rutkowski (2003), Lindeman, Rutkowsky, and Sluchynsky (2001), Lindeman, Rutkowsky, and Sluchynsky (2001), Müller (2001a, 2001b, 2003), Palacios and Pallarés (2000), Schwarz and Demirguc-Kunt (1999), and the Social Security Administration (1999).

[2] This is not exactly a notional accounts system.

[3] The Kyrgyz Republic's scheme, Palmer (2006), is incompletely designed regarding the rate of return, although given the long transition period, there is certainly time to improve the system design.

[4] This happens because it is a defined contribution system.

[5] A summary of the most relevant research on Spain can be found in the paper by Vidal-Meliá and Domínguez-Febián (2006).

of various notional retirement formulae similar to those actually applied in some countries would have had in Spain. They concluded that it would have noticeably decreased the amount of the pensions currently being paid, which are based on a traditional defined benefit formula. The real IRR expected from contributions would also have decreased from around 5.7 percent to less than 2.6 percent under any of the formulae applied. These values are more in line with the 3.6 percent real average growth of the gross domestic product (GDP) in Spain over the last forty years (1963–2002), which should undoubtedly be the benchmark to aim at for the system to be financially sustainable in the Samuelson sense.

In the next section we will define the concept of NDCs. In the third section we set out the projection model, which includes information obtained from Herce and Alonso's macroeconomic scenario 2000–2050 (2000), information about the past performance of the indices, and information relating to the time period of the projection. In the fourth section we use scenario generation techniques to present projections of the expected IRR for the beneficiary using six notional retirement formulae linked to the growth rate of a number of indices such as the retail price index (RPI), the GDP, the average earnings index (AEI), and the total Social Security contributions index (TSSCI). The results of the IRR calculations—average value, standard deviation, and value-at-risk (VaR)—are analyzed both in objective terms and for different degrees of participants' risk aversion via a utility function. The article ends with the main conclusions reached.

THE NOTIONAL DEFINED CONTRIBUTION ACCOUNTS MODEL

A notional account is a virtual account in which the contributor's individual contributions are collected along with the fictitious returns these contributions generate throughout the contributor's working life. Returns are calculated according to a notional rate, which could be the growth rate of the GDP, of average earnings, the wage bill, the income from total Social Security contributions, etc. When people retire they receive a pension based on the accumulated notional fund, the specific mortality rate for the cohort retiring that year, and the notional rate used.

At first glance notional defined contribution plans appear to be just an alternative way of calculating the amount of retirement pensions. The account is called notional because it exists only on paper. Money is not deposited in any real account. Nevertheless, the amount of the pension is based on the fund accumulated in the notional account. Contributions made to notional accounts are capitalized at a notional rate of return. This hypothetical return is normally linked to some external index set by law. Whatever index is used, the contributions are capitalized at a hypothetical rate of return, although this is expressed only on paper.

The conversion factors are not based on the same elements used by insurance companies, since no annuity is actually bought from an insurer. The factor used in these systems is a mechanism for converting the accumulated fund into a lifetime annuity. Nevertheless, this calculation has a real impact since it determines the pension that will actually be paid to the beneficiaries when they become pensioners at retirement age.

To summarize, NDCs tie benefits closely to individual contribution history over an entire working life, but they credit those contributions with a notional interest rate instead of a market return. As mentioned above, NDCs contain no real capital that can be claimed at retirement as a lump sum or used to purchase an annuity in the private market. Instead, at the time of retirement the government converts the notional account balance into an annuity on the basis of cohort life expectancy, then finances this benefit on a PAYG basis.

Table 1 gives a brief analysis of the most relevant aspects applied in various countries where retirement formulae based on the notional model have been introduced. It compares how the pension systems are organized, the notional rates of return applied to capitalize the contributions, the basic features of the retirement pension formulae, how pensions in payment are adjusted, and the measures that each country has established for making the transition from a defined benefit to a defined contribution system.

Although the theory behind the notional account system seems clear, there is no single formula to be applied. Each country has "designed" one mathematical expression to calculate the notional amount accumulated for each individual and another one to determine their pension.

From the actuarial point of view, the notional accounts model follows the assumption that the contributor has actually reached retirement age, and therefore the contributions are made in reality and the pension will be received by him every year if he survives, as can be seen in Figure 1.

$W_t \cdot \mathrm{Cr}_t$ denotes the contributions made by the individual at age t. These are valued at a particular rate at age x_r (time of retirement). The total contributions give entitlement to an indexed lifetime annuity that the individual will receive during his retirement, with the initial pension being P_{xr}. At moment x_r the value of the actuarial pension is calculated by matching the contributions made during working life to future benefits. In this way the equation fulfills financial and actuarial principles.

Following the above procedure, the general formula for calculating the pension will be obtained by matching, at moment x_r, the accumulated notional fund (K) with the present actuarial value of the expected pension due:

$$\overbrace{\sum_{t=x_e}^{x_r-1} \mathrm{Cr_t} \cdot W_t \prod_{i=t}^{x_r-1} (1+r_i)}^{K} = P_{x_r} \underbrace{\sum_{t=x_r}^{w} \frac{(1+\beta)^{t-x_r}}{[(1+\rho)]^{t-x_r}} {}_{t-x_r}p_{x_r}}_{G=\frac{1}{g}} = P_{x_r} \ddot{a}_{x_r}^{\beta} = P_{x_r} \frac{1}{g}, \tag{1}$$

where x_e is the age of the individual upon entering the labor market, $\mathrm{Cr_t}$ is the contribution rate at moment t, ω is the age limit on the mortality table, W_t is the salary or contribution base at moment t, ρ is the technical interest rate used, r is the annual rate used to capitalize the contributions, r_i is the annual rate used to capitalize the contributions during period i, β is the annual rate used to determine the initial pension, P_{xr} is the pension at retirement age x_r, ${}_{t-xr}p_{xr}$ is the probability that an individual aged x_r will reach age t, or will live t–x_r more years, $\ddot{a}_{x_r}^{\beta}$ is the present value of a life annuity due of 1 per year, whereas x_r survives, increasing at the accumulative annual rate of

TABLE 1
Main Features of the Countries Selected with Notional Defined Contribution Accounts

Features/Countries	Brazil (1999)	Italy (1995–1997)	Latvia (1996)	Poland (1999)	Sweden (1998–1999)
Current pension system structure	Two-pillar system:	Two-pillar system:	Three-pillar system:	Three-pillar system:	Three-pillar system:
	1. Mandatory defined contribution (31%) pay-as-you-go system and notional retirement formula for private sector employees. Traditional pay-as-you-go with many privileges for civil servants.	1. Mandatory pay-as-you-go system with defined contributions (33%) and notional retirement formula.	1. Financed by pay-as-you-go, organized through notional accounts (20%).	1. Mandatory pay-as-you-go with notional philosophy (12.22%).	1. Financed by pay-as-you-go, organized through notional defined contribution accounts (16.5% of contributions)
	2. Complementary capitalization system organized through companies (moderately developed).	2. Incipient company-based complementary capitalization system.	2. Mandatory, comprising individual capitalization accounts, begun in 2001 and will grow in importance.	2. Mandatory capitalization, less important at the start (7.3%).	2. Mandatory, comprising individual capitalization accounts (2.5%).
			3. Voluntary, based on group plans, at present barely developed.	3. Voluntary capitalization.	3. Complementary, though very widespread, based on employer schemes.
Notional rate of return on contributions	Endogenous rate according to years contributed and retirement age.	Five-year average based on nominal GDP growth rate.	Growth rate of the covered wage sum.	75% of the covered wage sum.	Covered contributions per participant + automatic balancing

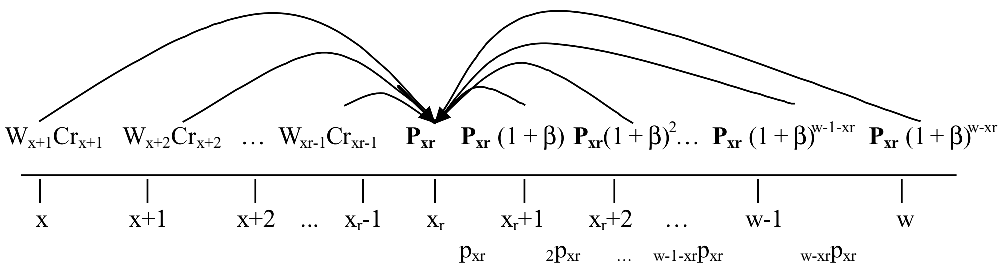
(continued)

TABLE 1
(Continued)

Features/Countries	Brazil (1999)	Italy (1995–1997)	Latvia (1996)	Poland (1999)	Sweden (1998–1999)
Main features of the retirement pension formula in pillar 1	Average of the 80% highest salaries, adjusted for inflation, divided by common life expectancy, multiplied by an implicit financial factor which depends on retirement age, number of contributions and contribution rate. Annual review of mortality tables.	Standard formula with conversion factor which includes survivor contingency. Retirement age from 57. Real interest rate of 1.5%. 10-year review of mortality tables.	Standard formula, similar to Equation (2), with common mortality tables, guaranteed minimum pension at 62, and contributions credited for certain periods.	Standard formula, similar to Equation (2), with common mortality tables, guaranteed minimum pension at 60 for women and 65 for men, and contributions credited for certain periods.	Standard formula with common mortality tables, guaranteed minimum pension at 61 and contributions credited for periods of unemployment, sickness, and temporary incapacity. Real rate of interest 1.6%.
Notional rate for pensions	RPI	RPI	Combination of price index and salaries.	RPI plus 20% of real wage growth, the latter by *ad hoc* political decision.	RPI plus/minus an adjustment for the difference between the real growth in salaries and that predicted.
Transitional measures	Yes, gradual application due to deficiencies in contribution records.	Yes, three retirement scenarios are superimposed: Amato Scheme, pro rata scheme, and Dini Scheme (entry into labor market from 1-01-96). Will be fully functioning in 2035.	Yes, visible mainly in the way the initial notional capital is determined. Problem with unreliable records.	Yes, the new formula for calculating pensions will not be fully in force until 2014 for men and to a certain extent from 2009 for women.	Yes, the new formula will only be applied 100% to those born from 1954 on. Will be fully in force before 2020.

Source: Chlon and Gora (2003); Gronchi and Nistico (2006); Lindeman, Robalino, and Rutkowsky (2006); Palmer (2006), and Vidal-Meliá and Devesa-Carpio (2004).

FIGURE 1
The Notional Accounts Model



β, with p being the technical interest rate used, K is the accumulated notional account, G is the inverse of the conversion factor, and g is the conversion factor.

The unknown factor of Equation (1) is the amount of pension that the worker will receive at the moment of retirement. This is because the later amounts are obtained by adjusting the initial pension in line with the rate chosen. We find the value of the pension at retirement age from

$$P_{x_r} = \frac{K}{G} = gK = g\sum_{t=x}^{x_r-1} \mathrm{Cr}_t \cdot W_t \prod_{i=t}^{x_r-1}(1+r_i), \tag{2}$$

where g is the g-value, predetermined conversion factor, which is equal to the inverse of the actuarial pension defined previously:

$$g = \frac{1}{\sum_{t=x_r}^{w} \frac{(1+\beta)^{t-x_r}}{[(1+\rho)]^{t-x_r}}\, {}_{t-x_r}p_{x_r}} = \frac{1}{\ddot{a}_{x_r}^{\beta}}. \tag{3}$$

On the other hand, if pension adjusting policy were designed in such a way that there was perfect indexation of pensions to the growth rate of the relevant variable, $(1+\beta) = (1+\rho)$, then the discount factor is equal to 1, and so the conversion factor becomes the inverse of life expectancy at retirement age plus 1:

$$g = \frac{1}{\sum_{t=x_r}^{w} {}_{t-x_r}p_{x_r}} = \frac{1}{1+e_{x_r}}. \tag{4}$$

Life expectancy would therefore appear explicitly in this transparent pension formula.

From the point of view of the system as a whole, according to Valdés-Prieto (2000), it is only with very strong restrictive conditions (constant productivity growth and a set demographic level) that automatic short-term financial sustainability can be maintained with an NDC system. This is logical since the financial system is still PAYG. Its financial viability has to be supported by known conditions based on the growth in number of contributors and real salaries, and according to Settergren and Mikula (2006), by other not so well-known conditions such as changes in mortality patterns. Valdés-Prieto (2000) shows that, even when applying the most favorable formula, notional accounts systems can only achieve this in a rather unrealistic steady state. Hence notional account systems always require other financial adjustment mechanisms—such as government guarantees and repeated recourse to legislation—to be imposed in the same way as traditional benefit systems, or according to Settergren (2001), special measures such as automatic adjustment mechanisms.

Lastly, as Brooks and Weaver (2006) point out, the complexity of NDCs provides great opportunities for politicians to conceal benefit retrenchment, whereas automatic adjustment mechanisms based on economic and demographic trends absolve politicians of responsibility for potential benefit reductions in the future.

FORECAST AND SIMULATION MODEL

Given the basic aim of this article—to quantify the risk to which any beneficiary entering the labor market would be exposed if a retirement pension system based on notional accounts were introduced—very long-term projections of macroeconomic variables will have to be made, since the projection period under consideration covers from the time a generation of 25-year-olds enters the labor market until the last pensioner dies, approximately 75 years later (depending on the mortality table used). As Herce and Alonso (2000) point out, establishing a macroeconomic scenario for 2050 is even more difficult than making demographic projections. Judging by the way the Spanish economy has changed over the last fifty years, any forecast for the next fifty is bound to be highly debatable. The complexity of economic reality makes economic forecasting an inherently difficult exercise, and this difficulty is reflected in the high level of uncertainty that normally accompanies it. Bearing this in mind, the logical attitude should be to try to adequately define the uncertainty rather than ignore it and give a false impression of rigor and accuracy.

The aim is not so much to estimate the future value of the parameters, but rather to evaluate the consequences for the beneficiary of a notional accounts system in an uncertain environment where the variables influencing the system follow different patterns of behavior. For this reason no econometric model is estimated and a more simplistic model is used. The work is based on a more intuitive model generated by the discrete form of an additive Brownian behavior of the parameters, without affecting the ability to include information about the past performance of the parameters.

Following Devolder (1993), the model used to obtain different tracks of behavior for the relevant indices (macroeconomic variables) is the following:[6]

$$I_t^s = \mu_{I,t} \pm \lambda^s \sigma_I \sqrt{t} \tag{5}$$

[6] Work has also been done with a formula that responds to a geometric Brownian motion: $I_t^s = \mu_{I,t} \exp[-\frac{\sigma_I^2}{2} t \pm \lambda^s \sigma_I \sqrt{t}]$. However, since these are very long-term forecasts, the effects of the positive scenarios are overrated while the effects of the negative scenarios are undervalued. With the geometric model, if the starting point is a positive value, then it is impossible to arrive at negative values. This is unreal since negative growth rates of the GDP or nominal salaries could exist in very unfavorable scenarios.

$$\forall I = \text{RPI}, \text{GDP}, \text{AEI}, \text{TSSCI},$$

where I_t^s is the value of arithmetic rate of index I, in period t and under scenario s, $\mu_{I,t}$ is the average value of the arithmetic rate of index I in period t, λ^s is the parameter generating scenario s, σ_I is the typical deviation of arithmetic rate of index I, RPI is the arithmetic rate of annual variation in retail prices, GDP is the arithmetic rate of annual variation in gross domestic product, AEI is the arithmetic rate of annual variation in average earnings, and TSSCI is the arithmetic rate of annual variation in total Social Security contributions.

This formulation is suitable for making forecasts, since

1) Information based on Herce and Alonso's macroeconomic scenario 2000–2050 (2000) is included, reflected in the model through parameter $\mu_{I,t}$. In other words, it is interpreted as the average value of the arithmetic rate of the index in question for each of the periods analyzed. This value includes the behavioral trend of the parameter.
2) Information about the past performance of the indices is incorporated through parameter σ_I, which gives information on the typical deviation of the average rate of the index in the historical series analyzed.
3) λ^s is a parameter generating the different scenarios.
4) With regard to long-term relationships, we suppose a perfect correlation between all the economic factors, and for this we use the same value of parameter λ^s for all the different indices. For instance, if the GDP is high for one scenario, then so is the RPI.
5) Finally, information relating to the period of time covered by the projection is included through term $\sqrt{t}$. This assumption is in relation to assumption 2, because we are working with linear variance and independent increments.

The model enables projections, known as scenarios, to be made of the behavior of the parameters. Each of these scenarios, $\forall s = 1, 2, \ldots, S$, has an associated probability of occurrence equal to p^s, $p^s > 0$, and $\sum_{s=1}^{S} p^s = 1$. There are two ways of working with scenarios:

1) those obtained through a distribution where a series of random numbers are generated; or
2) those that follow a distribution whose different parameters are known.

In the first case the optimal number of random number scenarios according to Mulvey and Ziemba (1998) is around 10,000 simulations. In the second case the number is lower, and so the simulation is much easier. Scenarios generated as in the second case are used in this article.

The most relevant data and assumptions when carrying out a simulation are as follows:

1) Number of scenarios $S = 20$.
2) Values of the generating parameter: identical increases and decreases relative to the average value have been assumed (Table 2).

3) Probability of each scenario: We assume that the distribution used is the one that assigns a greater probability of occurrence to those values closer to the average. This distribution of probability is subjective and may be different for each beneficiary (Table 3).

Tests have also been carried out with eleven more distributions in order to test the sensitivity of the results to the distribution used in generating the scenarios: 1. Uniform distribution. 2. Negative-biased distribution, assigning greater probability of occurrence to the scenarios that assume a decrease with respect to the average. 3. Positive-biased distribution, assigning greater probability of occurrence to the scenarios that assume an increase with respect to the average. It is clear that the results change with these distributions of probability. Subjective risk is being analyzed, but the same models still appear in the first three places. The authors have shown that, with all of them, the classification order in terms of individuals would hardly change, which gives an idea of the robustness of the results.

4) Periods: $t = 0,1,\ldots,75$. Age of contributor/beneficiary from 25 (entry into the labor market) to 100 (final age appearing in the INE 98–99 mortality tables). A study of past employment figures representative of the different Social Security contribution groups in Spain indicates that contribution periods barely cover thirty-five years. According to figures published for Spain, the average age for entering the jobs market is around twenty-five.
5) Years of evaluation: 2003, 2004, . . . , 2078.
6) Average value and past deviations of the parameters, in real terms.

Figure 3 shows the results of the projections for each of the twenty possible scenarios, for each of the macroeconomic variables in Table 4, and the last ten annual values. It is interesting to see how the shape of the graphs clearly illustrates the increasing uncertainty over time.

Details of how the macroeconomic scenario has been constructed can be found in the article by Herce and Alonso (2000). What most attracts the attention is the drastic change in the type of growth of the Spanish economy which, according to the authors, is caused by the great "manpower shortage" the Spanish economy will suffer from 2025 on. After 2025 it is the growth in productivity that becomes the key indicator of the economy's progress. The decrease in working population will become more and more obvious after 2020, given the stabilization of the rate of employment. Employment will enter a phase of negative growth. The economy will begin to shed jobs. The GDP will grow at a lower rate than productivity, and productivity will take over as the best indicator of the economy's progress.

Real salaries, which are the key for determining contributions as a whole, and employment will be growing at a lower rate than productivity, though following a similar pattern. The GDP deflator, which is assumed to be the same as the rate of inflation, maintains an annual growth rate of 2 percent throughout the period.

Alonso and Herce (2003) have carried out a new projection for the Spanish economy with the specific aim of evaluating the future perspectives of the Spanish pensions

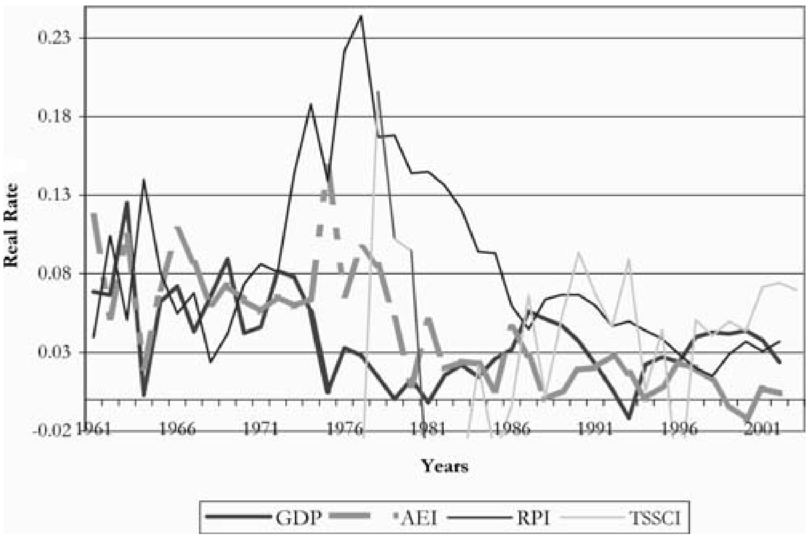
TABLE 2
Values of the Generating Parameter

S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
λ^s	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1	−0.01	−0.02	−0.03	−0.04	−0.05	−0.06	−0.07	−0.08	−0.09	−0.1

TABLE 3
Probability of the Scenarios

S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
p^s	0.085	0.077	0.069	0.062	0.054	0.046	0.038	0.031	0.023	0.015	0.085	0.077	0.069	0.062	0.054	0.046	0.038	0.031	0.023	0.015

FIGURE 2
Historical Evolution of the Various Arithmetic Rates in Spain (1961–2002)



Source: RPI: Instituto Nacional de Estadística (National Institute of Statistics [NIS]). AEI: 1964–1976 (Earnings per hour worked), 1976–1981 (Average monthly salary per working person), 1981–2002 (Average earnings per worker per month) from the Bank of Spain's Statistics Bulletin. TSSCI: Social Security contributions by employed workers (RGSS in Spanish), General Social Security and NIS Treasury Reports. GDP: NIS Statistics Yearbook and the Bank of Spain's Statistics Bulletin.

system. Assumptions regarding the future course of growth in employment, working population, productivity, earnings, and inflation are combined—given the operating rules of the pension system—to enable forecasts to be made of the series of affiliates, pensioners, contributions income, and spending on contributory pensions. The projections form a "central scenario" which could be judged as more or less optimistic depending on the assumptions adopted.

As far as pensions are concerned, it is considered normal for projection exercises to be repeated at regular intervals to take into account new economic and demographic circumstances, changes in legislation, improvements in methodology, and the need to explore new hypotheses. In the results presented below, reference is made to this new macroeconomic scenario.

ANALYSIS OF THE AGGREGATE SUBJECTIVE ECONOMIC RISK TO BENEFICIARIES

The beneficiaries of pension systems are exposed to a number of risks (Valdés-Prieto 2002), which can be divided into diversifiable and nondiversifiable. The first group includes those that act in an uncoordinated way on the various members of the group. Nondiversifiable risks are those which materialize simultaneously either in a coordinated way or with a high level of correlation. Table 5 classifies nondiversifiable risks.

FIGURE 3
Evolution and Projection of the RPI, AEI, TSSCI, and GDP

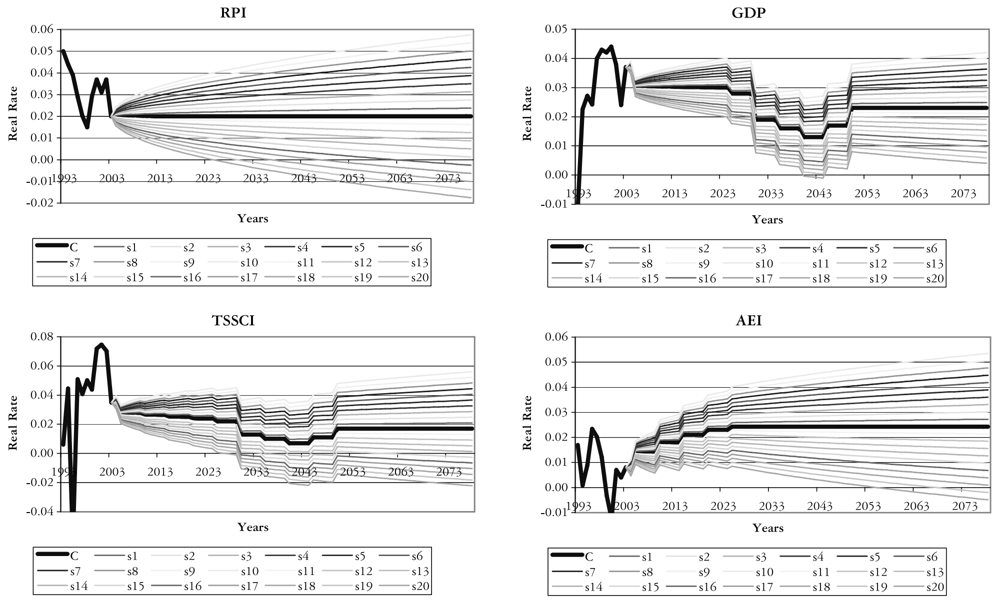


TABLE 4
Average Values and Past Deviations of the Various Indices in Real Terms

	Year	2003	2005	2010	2015	2020	2025	2030	2035	2040	2045	>2050
Past Deviations[7]	T	0	3	7	12	17	22	27	32	37	42	>47
σ_{GDP}: 0.0219	$\mu_{\mathrm{GDP},t}$	0.037	0.030	0.030	0.030	0.030	0.028	0.019	0.016	0.013	0.017	0.023
σ_{RPI} :0.0434	$\mu_{\mathrm{RPI},t}$	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
σ_{AEI} :0.0337	$\mu_{\mathrm{AEI},t}$	0.008	0.014	0.018	0.021	0.023	0.024	0.024	0.024	0.024	0.024	0.024
σ_{TCSSI} :0.0452	$\mu_{\mathrm{TCSSI},t}$	0.035	0.027	0.026	0.025	0.024	0.022	0.013	0.010	0.007	0.011	0.017

Source: Authors, based on Herce and Alonso (2000).

Financial risks would almost exclusively affect capitalization systems. Economic risks would have a greater impact on PAYG systems, with NDCs being especially sensitive. Demographic risks would affect both PAYG and capitalization systems, but the effect would be more immediate on the PAYG ones. Lastly, political risks appear to a great extent in defined benefit PAYG systems, with NDCs being fairly immune. This is precisely one of the greatest advantages of NDCs.

The beneficiary is subject to risk in that he does not know for certain what the IRR on his contributions will be. The *aggregate*[8] *subjective economic* risk for the beneficiary

[7] See Figure 2.
[8] This is called aggregate since only average rather than individual salary paths are considered.

Table 5
Classification of Nondiversifiable Risks in Pension Systems

Types of Risk	Risk Origin Factors		
Financial risk	From capital From reinvestment From inflation		
Economic risk	From the growth of unemployment From the reduction in the growth rate of the GDP From the reduction in the growth rate of real salaries		
Demographic risk	From the increase in longevity of the population From the decrease in the rate of fertility From the growth of the net emigration rate From the reduction in the rate of activity		
Political risk	From the reduction in the promised pension	Implicit Explicit	Inflation Δ Retirement age ∇ Replacement rate Δ Requirements

Source: Authors based on Valdés-Prieto (1998 and 2002).

is defined as the possibility that the rate of return on the contributions paid may not coincide with the expected rate due to the uncertain return on an economic asset (behavior of salaries, of the GDP, of the contributing population, etc.) which supports the notional retirement accounts and should be an indicator of the system's financial health. According to Table 5, the risk being quantified would mainly be economic risk, but this would also be influenced by demographic elements which alter economic activity. To quantify this risk it will be necessary to calculate how the return on contributions deviates from its expected value. This can be measured either by the typical variance or deviation of the IRR random variable associated with the contributor–beneficiary's contributions, or by the VaR. Measuring (subjective) risk by using the VaR is the method closest to the traditional definition in the world of insurance: uncertainty about the occurrence of an event (each of the proposed scenarios) and the harmful consequences this event may bring (IRR less than expected, because if it is greater the consequence is not harmful).

The behavior of the arithmetic rates used as notional adjustment rates (see Table 6) for contributions and pensions is random, and this randomness is taken into account by the scenarios. This means that the IRR obtained from the equivalence between the amounts "tracked" in the notional account and the pensions also has an uncertain behavior pattern associated with each of the scenarios.

A scenario generation model is used to measure economic risk to beneficiaries, enabling IRR behavior tracks to be projected into the future. This model quantifies the effect of the deviations brought about by the behavior of the real IRR when there are deviations in the economic parameters that affect the way it is calculated.

TABLE 6
Formulae for Calculating the Initial Pension and Its Later Variation

Model[9]	Revaluation of the Contribution Base	Notional Rate for Contributions	Notional Rate for Pensions
1	RPI	GDP	RPI
2	RPI	GDP	RPI ± AEI differential
3	RPI	TSSCI	RPI ± TSSCI differential
11	AEI	GDP	RPI
12	AEI	GDP	RPI ± AEI differential
13	AEI	TSSCI	RPI ± TSSCI differential

Because the analysis of economic risk to beneficiaries is closely related to the concept of real IRR, the IRR must be precisely defined. According to Devesa-Carpio, Lejárraga-García, and Vidal-Meliá (2000), the apparent *a priori* expectation of real IRR for a contributor entering the labor market at age x_e in a pure PAYG system with retirement benefits, assuming the system's rules remain constant, is defined as the parameter of value *IRR* of the law of compound capitalization, which actuarially matches the flow of contributions with the flow of benefits.

The real IRR, for each scenario s, is determined from the following equation:

$$\sum_{x=x_e}^{x_r-1} \mathrm{RAC}_x^s (1+\mathrm{IRR}^s)^{-(x-x_e)} = \sum_{x=x_r}^{\omega} \mathrm{RAP}_x^s (1+\mathrm{IRR}^s)^{-(x-x_e)}, \tag{6}$$

where RAC_x^s is the real actuarial contribution paid at age x under scenario s, RAP_x^s is the real actuarial pension received at age x under scenario s, and IRR^s is the internal rate of return under scenario s.

The value of the real actuarial contribution for a person aged x:

$$\mathrm{RAC}_x^s = \mathrm{Cr}_x W_x^s \, {}_{x-x_e}p_{x_e}, \tag{7}$$

Where Cr_x is the contribution rate at age x. This is assumed to be equal to 15 percent throughout the period. This is obtained as an approximation, given that in Spain there is no legally established allocation for retirement contingency. It has been considered that, according to data from the Social Security budget, out of the total contributions for common contingencies applicable in the general employed worker system, a 15 percent contribution rate will be assigned to the retirement contingency.

[9] In addition to those included in Table 6, ten other models were also worked on. However, their results are not shown because they are less interesting, and including them could divert the reader's attention away from the most relevant results.

W_x^s is the salary base at age x under scenario s, and ${}_{x-x_e}p_{x_e}$ is the probability that an individual of age x_e will reach age x.

The real actuarial pension at age x is the real value of the pension affected by the probability of survival from the moment of entry into the labor market:

$$\mathrm{RAP}_x^s = P_{x_r}^s\,{}_{x-x_e}p_{x_e}\prod_{t=x_r}^{x}\left(1+\alpha_t^s\right), \tag{8}$$

where P_{xr}^s is the initial pension (at retirement age x_r), obtained (see Equation (2)) according to the notional capital accumulated under scenario s, α_t^s is the arithmetic rate used to increase pensions under scenario s.

The determination of the IRR for each scenario s can also be expressed directly with the following equation:

$$\sum_{x=x_e}^{x_r-1}\left[\mathrm{Cr}_x W_x^s\,{}_{x-x_e}p_{x_e}\right](1+\mathrm{IRR}^s)^{-(x-x_e)} = \sum_{x=x_r}^{\omega}\left[P_{x_r}^s\,{}_{x-x_e}p_{x_e}\prod_{t=x_r}^{x}(1+\alpha_t^s)\right](1+\mathrm{IRR}^s)^{-(x-x_e)}. \tag{9}$$

The models based on the notional defined contribution account system used for calculating the initial retirement pension and its later variation are the following.[10]

When the notional rate for pensions in the formulae in Table 6 shows, for instance, RPI ± AEI differential, this means that pensions already in payment will be adjusted according to the RPI plus a positive or negative differential. In this example the differential depends on the behavior of the real AEI for each scenario relative to the expected AEI (average value). If the real AEI is greater than the expected one or the benchmark, then the variation for pensions in payment will be greater than the RPI. If the opposite is true, then it will be less. The other benchmark macroeconomic variables operate in the same way. This system of increasing pensions is inspired by the Swedish experience (see Table 1). The assumption that the correlation between the indices is perfect validates working on one model with different indices.

If the average expected replacement rate (RR) is analyzed with each of these models, because a number of them use the same indices to calculate the increase of contributions and the notional rate, then the six models analyzed can be broken up into four groups, the first two of which show very similar results.

Table 7 shows the RR amounts for each of these groups. The first group, which assumes that the revaluation of the contribution base is in line with the AEI and that the capitalization of contributions is also carried out according to the GDP, is the one that generates the highest RR. In a first approach it could be said that, of the models analyzed, those belonging to the first group are those which any well-informed beneficiary would choose *a priori*. Indeed, all those with contribution bases that vary in line with the AEI are preferable, in terms of the average expected RR, to those which

[10] The fact that we use different indices in the same model illustrates the importance of our assumption between these factors.

TABLE 7
Average Expected RR

Average expected RR	Model	Group
46.43%	11–12	1
46.39%	1–2	2
41.27%	13	3
41.24%	3	4

Retirement age 65.

follow the RPI. This is because a higher RR is achieved in models where a greater contribution effort is made.

Another thing that attracts the attention is the value of the RR. After forty years of contributing, the formula that provides the best RR is the one for around 46.5 percent. This is in sharp contrast to the RR currently supplied by the system, which is around 92 percent. If the notional accounts system were applied, in the best of cases the initial pension would reach 51 percent of that obtained under the present PAYG system in Spain. If people started work at twenty instead of twenty-five, these RRs would be slightly higher, reaching 49 percent in the case of group 1.

Much of the above difference can be attributed to the way the current pension calculation formula is designed. According to Devesa-Carpio and Vidal-Meliá (2004), if, instead of taking the last fifteen years of contributions into account to calculate the regulating base, the whole working life were considered—as is advisable in contributory systems which aim at proportionality—the RR would have been about 75 percent for a person retiring at age 65 with forty years of contributions.

The information in Table 7 is valid for carrying out a first comparative analysis between the different models. To analyze economic risk to beneficiaries, various moments of the IRR distribution, such as the average, the deviation, and the VaR, need to be calculated. In no case can the average RR be a good indicator of the aggregate economic risk since it would only take account of the randomness associated with the "capitalization" of the contributions, leaving aside the randomness associated with the adjustment (increase) of those pensions already in payment.

The results obtained for the average expected IRR are shown separately for men and women in Table 8. Also shown is the percentage of expected deviation from the IRR for each model. Five basic aspects need to be highlighted:

1) The analysis of the average IRR shows clear differences between men and women. This discrepancy comes about because the joint average life expectancy of men and women at retirement age was used when calculating the initial pension. Given that women have a higher life expectancy, the expected return on their contributions is much higher.
2) If Tables 7 and 8 are compared, no clear relation between the RR and the IRR can be seen. This is because the RR refers exclusively to the initial pension and, in addition, the contribution effort made is not taken into account. The IRR, however,

TABLE 8
Average Internal Rate of Return (IRR) and Expected Deviation for Men (M) and Women (W)

Model	IRRM Average	IRRM Deviation	% DevM	IRRW Average	IRRW Deviation	% DevW
12	0.02492	0.01148	46.06%	0.03441	0.01192	34.64%
1	0.02486	0.00796	32.02%	0.03435	0.00823	23.94%
11	**0.02483**	**0.00791**	**31.84%**	**0.03433**	**0.00819**	**23.86%**
3	0.02097	0.01651	78.73%	0.03064	0.01682	54.89%
13	***0.02097***	***0.01651***	***78.74%***	***0.03064***	***0.01682***	***54.91%***
2	0.01926	0.00729	37.84%	0.02845	0.00755	26.56%

Retirement age 65.

relates all the probable inflows and outflows, and takes into account how the pension can vary over time.

3) There are only very small differences between the real average expected IRR for both men and women in the first three models. This appears to indicate that the participant–beneficiary could choose any of them using his or her degree of risk aversion as a basis for making the decision.

4) The values obtained for the real IRR appear to be surprisingly low, but in fact they are not as low as they seem since the calculation is being considered *a priori*. The values will increase proportionally as the contributor is assumed to grow older. With similar assumptions, and assuming current Spanish legislation constant for the whole time period considered, the real IRR would be 4.05 percent and 4.93 percent for men and women, respectively. However, it would be best to qualify the above figures since the value of the IRR in the defined benefit PAYG system does not include possible future reductions in its value since it is calculated in a system which presupposes financial equilibrium. Future pensioners will probably have to make greater contributions (through tax increases) and/or receive smaller pensions. In other words, if the defined benefit system intends to respect its acquired commitments to members, it must be because available financial resources exist to cover the system's future deficit. If these funds were used in the notional accounts system, this would provide a larger pension, thereby reducing the IRR differential.

5) The average values undergo deviations, which imply that those models that generate a greater deviation of the IRR relative to the average IRR are riskier. The ranking in order of deviation is the same for men and women as they depend on the same volatility factors. Model 13 is seen as showing the highest risk in terms of typical deviation, whereas Model 11 has the least. In general terms, IRR deviation for women is greater than for men.

Looking from the perspective of risk, an interesting instrument to apply is the VaR. As Jorion (1997) writes, "VaR summarize the expected maximum loss (or worst loss) over a target horizon within a given confidence interval."

TABLE 9
$VaR_{(0.95)}$ for Expected IRR for Men (M) and Women (W)

$VaR_{(0.95)}$ IRRM	Model	$VaR_{(0.95)}$ IRRW	Model
0.01051	11	0.01953	11
0.01050	1	0.01950	1
0.00604	2	0.01485	2
0.00429	12	0.01300	12
−0.00927	3	−0.00015	13
−0.00928	13	−0.00017	3

Retirement age 65.

In the analysis below, this expected loss is taken to be the minimum value of the IRR. For δ percent probability, and provided that the conditions in the scenario generation model are maintained, the minimum IRR value for each of the models is expressed as

$$VAR_{\delta}(IRR) = F^{-1}_{IRR^s}(1-\delta) = \mathrm{Sup}\left[IRR^s : F_{IRR^s}(IRR^s) \leq (1-\delta)\right], \tag{10}$$

where $F^{-1}_{IRR^s}(1-\delta)$ may be seen to be the inverse of the distribution function of the random IRR variable for an accumulated probability of $(1-\delta)$; i.e., the $(1-\delta)$ centile.

Clearly those alternatives with a lower $VaR_{0.95}$ imply greater risk. It can be seen from Table 9, where $VaR_{0.95}$ is calculated, that the results for men and women coincide in most cases. For both men and women the models that provide least value are 3 and 13. The three models with the least risk for both men and women are 11, 1, and 2.

If the beneficiary is a notional rate for pensions (Models 3 and 13), there is a 95 percent chance of his IRR being greater than –0.93 percent (–0.017 percent). However, if the same man chooses GDP as a man (woman) who decides to use the TCSSI as a notional rate for contributions and the RPI ± TCSSI differential notional rate for contributions and RPI as a notional rate for pensions (Models 1 and 11), there is a 95 percent probability that his IRR could be greater than 1.05 percent (1.95 percent).

In the Model 11 hypothesis, the VaR for men ($VaR_{0.95}$ IRRM = 0.0105) means a 58 percent reduction in average expected IRR (IRRM average = 0.0248), whereas for women the VaR reduction in average expected IRR is around 44 percent. For Model 1 the result is very similar. The men's VaR is lower than the women's, and so women therefore run less risk.

If, instead of taking the Herce and Alonso (2000) article as a starting point to develop the scenarios, the most recent version—Alonso and Herce (2003)—had been used, the results would point to a greater risk, a lower RR, and a lower expected return for the beneficiaries.

Subjective Economic Risk to Beneficiaries and Risk Aversion

In order to carry out a complete risk analysis, the beneficiary's subjectivity in evaluating risk through his risk aversion must be introduced. The risk analysis will be made in terms of the expected capitalization factor associated with the IRR: (1 + IRR), which represents the value accumulated thanks to this return. Thus, if the function used quantifies the beneficiary's attitude to risk, the choice of model obtained will follow this criterion or value, with the beneficiary opting for riskier models when the function reflects that he is less averse to risk, and more conservative models the more averse to risk he is.

The utility function used—CRRA family—is as follows:

$$U(1+\text{IRR}) = \begin{cases} \dfrac{(1+\text{IRR})^{1-\gamma}}{1-\gamma}, & \text{if } \gamma \neq 1 \\ Ln(1+\text{IRR}), & \text{if } \gamma = 1, \end{cases} \tag{11}$$

where $\gamma > 0$, parameter that quantifies risk aversion. The higher γ is, the greater the risk aversion will be. If $\gamma = 0$, the individual is neutral to risk.

For each model we will calculate the value of expected utility as follows:

$$E[U(1+IRR)] = \sum_{S=1}^{S} p^S U(1+IRR^S). \tag{12}$$

The beneficiary will choose whichever model supplies the greatest value for this function, in relation to his risk aversion. The option chosen by an individual who is neutral to risk coincides with the maximization of the average IRR.

Different risk aversion coefficients are assumed, classified as shown in Table 10. Those beneficiaries with greater risk aversion (10) choose Model 1 for preference. This model is one of those that represent less risk in VaR terms, and the combination of average IRR and deviation of IRR represents the second lowest risk. With a low-risk aversion coefficient (1), the optimal choice is the same as in the neutral case since much greater weight is given to the IRR.

The results for women are almost identical to those for men.

TABLE 10
Classification of Formulae for Men According to Their Aversion to Risk

$\gamma = 0$ neutral	$\gamma = 1$	$\gamma = 2$	$\gamma = 5$	$\gamma = 10$
12	12	1	1	1
1	1	12	11	11
11	11	11	12	12
3	3	3	3	3
13	13	13	13	13
2	2	2	2	2

Retirement age 65.

Subjective Economic Risk to Beneficiaries and Retirement Age

One of the theoretical advantages of the notional accounts system is that it more directly reflects the individual's preferences with regard to the pension they wish to receive at the end of their working life, since the system manages to tighten the pension–contribution relationship and therefore achieves greater equality or "actuarial fairness." According to Williamson (2004), NDCs are designed to reward those who remain longer in the labor force and penalize those who retire early. It is interesting to study whether retiring earlier or later than the accepted benchmark retirement age would have any great effect on the risk faced *a priori* by the beneficiary. With this end in view two suppositions are made:

1) The beneficiary takes early retirement at age sixty.
2) The beneficiary defers retirement until age seventy.

Table 11 shows the results for the RR when the beneficiary retires at sixty-five, and the reduction coefficient for each of the suppositions put forward. In this table, the models are ordered by the numerical value of the RR, from highest to lowest. If the beneficiary retires before sixty-five, the reduction coefficient is simply rate 60 divided by rate 65. If the coefficient is less than 1 it implies a penalty because the initial pension is decreased, whereas if it is greater than 1 the effect is reversed.

The adjustment coefficient is less than 1 when the beneficiary takes early retirement at sixty and greater than 1 when retirement is deferred until age seventy.

The RR increases with age and the number of years contributions have been paid. The disincentive to work brought about in a badly designed defined benefit PAYG system therefore seems to be mitigated.

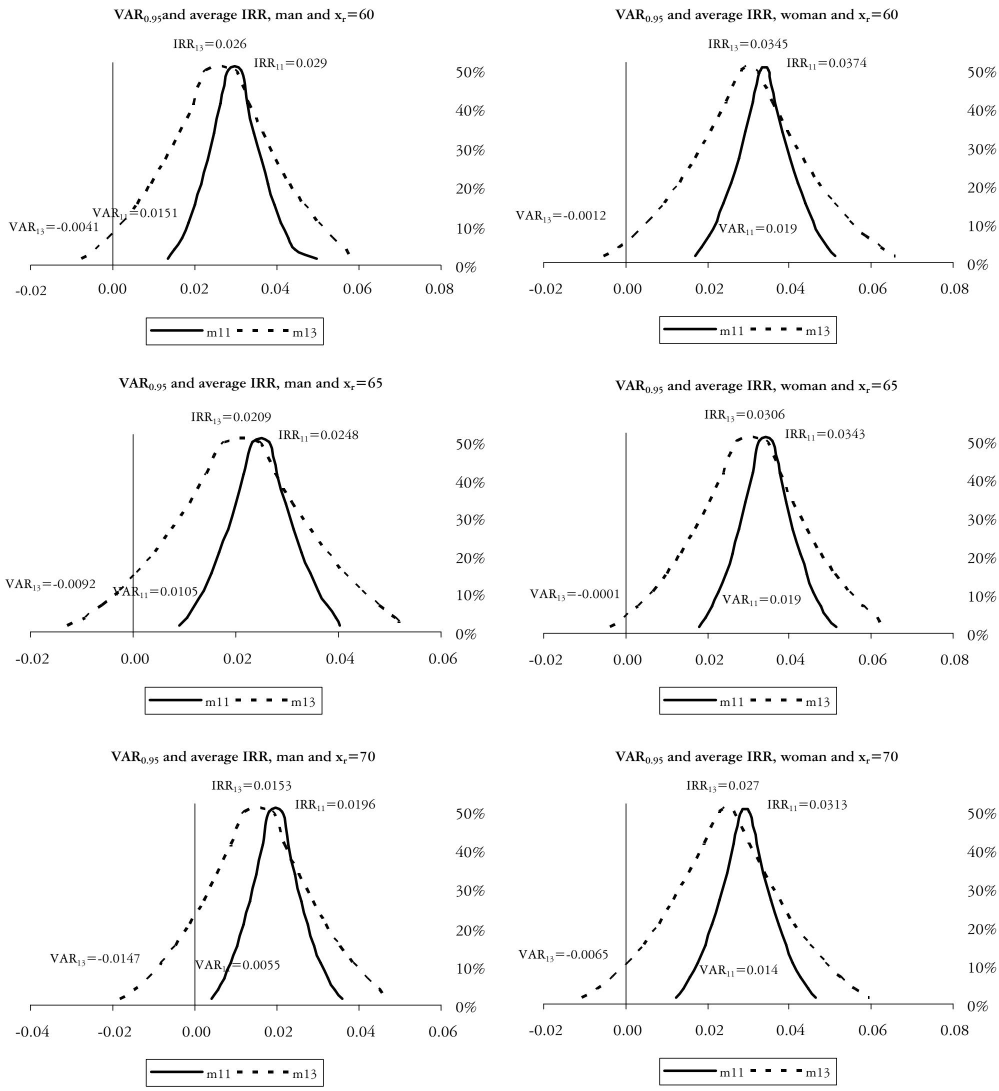
The cancellation or weakening of this disincentive to work is questionable if the data for the average expected IRR are analyzed. The results of this are shown in Figure 4, which includes the $VaR_{0.95}$ and average IRR for the riskiest and least risky models (13 and 11, respectively) for both men and women and different retirement ages. It can be seen that for both men and women the average IRR decreases with age and the number of years contributions have been paid. This clearly indicates that the cancellation of the work disincentive effect is much more apparent than real. Furthermore, from the point of view of the expected return on contributions, any of the formulae tested would bring about the opposite effect to that expected.

TABLE 11
Average Expected Replacement Rate for $x_r = 65$ and Adjustment Coefficient for $x_r = 60$ and $x_r = 70$

60 Years		Model	65 Years	Model	70 Years		Model
0.784	36.39%	11–12	46.44%	11–12	1.307	60.70%	11–12
0.775	35.94%	1–2	46.40%	1–2	1.305	60.54%	1–2
0.800	33.03%	3	41.28%	13	1.291	53.29%	13
0.801	33.02%	13	41.24%	3	1.289	53.15%	3

FIGURE 4

$VaR_{0.95}$ and Average IRR for the Riskiest (m13) and Least Risky (m11) Models, for Men and Women and Different Retirement Ages



In terms of risk as measured from the perspective of the $VaR_{0.95}$, it would not appear to be a good decision *a priori* to delay the age of retirement and pay contributions over more years either, since the expected result is unfavorable for both men and women. It could be said that it is riskier to retire at seventy than at sixty, since the extreme IRR values are lower at seventy than at sixty. If it were considered, as Valdés-Prieto (2002) suggests, that by taking early retirement the retiree has more leisure time—which is valued very positively—then the conclusions reached would be strengthened even more in the sense that taking early retirement would imply a greater expected return, less risk to bear, and greater leisure opportunities.

One of the criticisms usually made of notional accounts systems, as pointed out by Disney (1999), is that the contributors take on the risk of the evolution of the arithmetic rate and are subject to a risk-return trade-off they have not chosen, i.e., their aversion to risk is not taken into account like it is in private capitalization funds. One way of avoiding this problem would be to have a menu of retirement formulae available, like those proposed for Spain, then every three or four years or so the contributor could change the contribution variation rate according to his perception of risk and the evolution and envisaged path of the indices.

Involving the individual in taking decisions as to the model he considers most suitable will make him feel much more committed to the NDC system, which is essentially much more robust financially than the defined benefit system and minimizes the risk of political manipulation as the benefits cannot be increased arbitrarily. This does not mean that there are no mechanisms to safeguard the financial equilibrium of the system in case of economic and/or demographic shocks. In practice, as mentioned above, Settegren (2001) points out that some countries have mechanisms to stabilize the system in case serious financial imbalances appear.

All the results shown in section "Analysis of the Aggregate Subjective Economic Risk to Beneficiaries" were obtained by taking into account a single probability distribution, which was considered logical and appropriate, but defined subjectively. The risk analysis, as mentioned earlier, was carried out for other types of distribution: a uniform distribution, a biased distribution which assigns greater probability to negative values and would correspond to a pessimistic individual, and a positive-biased distribution, which would correspond to an optimistic individual. The number of distributions was increased working with different degrees of optimism and pessimism, with a final total of eleven probability distributions obtained.

The results[11] show that, for all the distributions analyzed, Models 3 and 13 are those that imply the greatest risk and would therefore never be chosen by the beneficiary. Models 1 and 11, on the other hand, present the least risk and are the ones individuals prefer. These rankings coincide with the results shown, thereby confirming that the results are robust.

CONCLUSIONS AND FUTURE RESEARCH

An unexplored aspect of NDCs is the study and quantification of the subjective economic risk faced by the contributor–beneficiary. In this article we have estimated the aggregate subjective economic risk to which the beneficiary would be exposed if a retirement pension system based on notional account philosophy were to be introduced. For this we have used scenario generation techniques to make projections of the factors determining the real expected internal rate of return (IRR) and the expected RR for the beneficiary according to six retirement formulae. The results of the IRR calculation—average value, standard deviation, and VaR—have been analyzed both in objective terms and for different degrees of participants' risk aversion. The

[11] The results are available on request from the author.

model has been applied to the case of Spain, but it could equally be applied to any country with reliable historical macroeconomic data and reasonable projections.

The *a priori* average expected IRR for both men and women following any of the formulae tested based on representative indices of relevant macroeconomic variables is quite clearly lower than the IRR awarded today on contributory retirement pensions by current Spanish legislation. The envisaged RR in the most favorable formula barely reaches 50.5 percent of that obtained today. This only goes to highlight the profound structural actuarial imbalance present in the current configuration of the defined benefit retirement pension system in Spain.

The preferred models for both male and female beneficiaries who are neutral to risk are 12 and 1, in descending order. Both models capitalize the contributions in line with the expected evolution of the GDP. In Model 12, the pensions can participate in the probable upward fluctuations of the salaries index above that foreseen, although they cannot in Model 1.

Taking the degree of risk aversion into account slightly changes the preferences established by following only the criterion of average expected IRR. Individuals with a more marked aversion to risk, both men and women, would always choose Model 1 first, opting next for Model 12 according to how their attitude to risk tends toward neutral.

From the point of view of risk to be born as measured by the VaR, the three models proposed that have the lowest value and therefore less risk are 11, 1, and 2, for both men and women. Models 1 and 11 use the expected GDP and RPI as a notional rate for contributions and pensions in payment, respectively, whereas Model 2 also uses the GDP for the capitalization of contributions, although, the pensions already in payment can participate in the probable upward fluctuations of the salaries index above that foreseen. In any case, the minimum level of IRR in the best model (Model 11), 1.05 percent and 1.95 percent for men and women, respectively, would be substantially less than the IRR stemming from current legislation, 4.05 percent and 4.93 percent for men and women, respectively, under the highly improbable supposition that the system could be maintained without changes in regulations for the whole of the time period of the projection. It is clear that the political risk that the pension promised under current Spanish legislation will be reduced is extremely high for current contributors.

The effect of deferring retirement age, although, providing a higher expected RR for all the models studied and an adjustment coefficient greater than one, seems to corroborate that these systems really do provide a disincentive to leave the labor market. At the same time, other effects of deferring retirement age are a lower expected IRR and a greater risk to be faced. This would suggest that the possible introduction in Spain of any of the models studied would need some sort of correctional element in order for it not to bring about the opposite effect to that desired in the form of growing risks and decreasing returns.

An important aspect to highlight is that, if a notional accounts system were introduced, it would be best if contributors were able to change the notional rate on contributions at regular intervals, like in individual capitalization account systems, so as to adjust it to their perception of risk and to the predicted evolution and path of the indices.

Finally, future research should be directed toward perfecting the scenario generating model. An alternative could be a relaxing of the assumption that there is a perfect correlation between the indices analyzed, which would mean carrying out a statistical analysis of the behavior of the time series. Another alternative could be that of not presetting the distribution values, and generating a normal distribution (0, 1) through a Montecarlo simulation. The greatest difficulty with this alternative is that the number of scenarios would increase greatly, but then again the paths might behave more in line with macroeconomic reality. Lastly, with regard to assessing beneficiary risk in subjective terms, apart from considering the analysis of the IRR via the Markowitz function, the analysis could be extended by assessing the expected utility of the future pension throughout the time horizon.

References

Alonso, J., and J. A. Herce, 2003, Balance del sistema de pensiones y boom migratorio en España. Proyecciones del modelo MODPENS de FEDEA a 2050. *FEDEA*, DT 03-02.

Boldrin, M., J. Dolado, J. Jimeno, and F. Peracchi, 1999, The Future of Pension Systems in Europe. A Reappraisal, *Economic Policy*, 29 October: 283-323.

Börsch-Supan, A., R. Palacios, and P. Tumbarello, 1999, *Pension Systems in the Middle East and North Africa: A Window of Opportunity* (Mimeo: The World Bank).

Brooks, S. M, and R. K. Weaver, 2006, Lashed to The Mast?: The Politics of Notiosnal Defined Contribution Pension Reforms. Chapter 14 in: R. Holzmann, and E. Palmer, eds., *Financial Defined Contribution (NDC) Pension Schemes: Concept, Issues, Implementation, Prospects* (The World Bank and Riksforsakrings Verket).

Chlon, A., and M. Gora, 2003, The NDC System in Poland. Assessment After 5 Years. Presented at the Conference on NDC Pensions 28–30 Sept., at World Bank and Riksforsakrings Verket, Sandhamn, Sweden.

Devesa-Carpio, J. E., and C. Vidal-Meliá, 2001, *Current Status and Provisional Assessment of Reformed Pensions Systems in Latin America*, Pension Reform Primer, (Washington, DC: The World Bank).

Devesa-Carpio, J. E., and C. Vidal-Meliá, 2004, Notional Defined Contributions Accounts (Ndc's). What Effect Would They Have Had on the Spanish Pension System? *Moneda y Crédito*, 219: 61-103.

Devesa-Carpio, J. E., A. Lejárraga-García, and C. Vidal-Meliá, 2000, The Internal Rate of Return of the Pay-As-You-Go System: An Analysis of the Spanish Case, *Centre for Pensions and Social Insurance*, Research Report 33/2000 Birkbeck College and City University of London.

Devolder, P., 1993, *Finance Stochastique* Collection Actuariat. Université de Bruxelles.

Disney, R., 1999, Notional Accounts As a Pension Reform Strategy: An Evaluation, *Pension Reform Primer* (Washington DC: The World Bank).

Fox, L., and E. Palmer, 2000, *New Approaches to Multipillar Pension Systems: What in the World Is Going On?* (Washington DC: The World Bank).

Fox, L., and E. Palmer, 2001, Pension Reform in Europe in the 90's and Lessons for Latin America, *Serie Financiamiento del Desarrollo* 114 CEPAL.

Gillion, C., 2000, The Development and Reform of Social Security Pensions: The Approach of the International Labour Office, *International Social Security Review*, 1(53), 35-62.

Gronchi, S., and S. Nistico, 2006, Fair and Sustainable Pay-As-You-Go Pension Systems: Theoretical Models and Practical Realizations. Chapter 19 in: R. Holzman, and E. Palmer, eds., *Financial Defined Contribution (NDC) Pension Schemes: Concept, Issues, Implementation Prospects* (The World Bank and Riksforsakrings Verket).

Herce, J., and J. Alonso, 2000, La reforma de las pensiones ante la revisión del Pacto de Toledo, *Colección Estudios Económicos* (19) La Caixa.

Holzmann, R., 2000, The World Bank Approach to Pension Reform, *International Social Security Review*, 1(53): 11-34.

Holzmann, R., 2006, Toward a Reformed and Coordinated Pension System in Europe: Rationale and Potential Structure. Chapter 11 in: R. Holzmann, and E. Palmer, eds., *Financial Defined Contribution (NDC) Pension Schemes: Concept, Issues, Implementation, Prospects* (The World Bank and Riksforsakrings Verket).

Holzmann, R., L. MacKellar, and M. Rutkowski, 2003, Accelerating the European Pension Reform Agenda: Need, Progress, and Conceptual Underpinnings. Chapter 1 in: R. Holzmann, M. Orenstein, and M. Rutkowski, eds., *Pension Reform in Europe: Process and Progress* (Washington DC: The World Bank).

Holzmann, R., M. Orenstein, and M. Rutkowski, 2003, *Pension Reform in Europe: Process and Progress* (Washington DC: The World Bank).

Hoskins, D., 2003, Whither the Pension Reform Debate? Some Reflections, *The Geneva Papers of Risk and Insurance*, 4(28): 682-685.

Jorion, P., 1997, *Value At Risk* (Chicago: Irwin).

Lindeman, D., M. Rutkowsky, and O. Sluchynsky, 2001, The Evolution of Pension Systems in Eastern Europe and Central Asia: Opportunities, Constraints, Dilemmas and Emerging Best Practices. Presented at the Second OECD forum on Private Pensions, Sofia, Bulgaria.

Lindeman, D., D. Robalino, and M. Rutkowsky, 2006, NDC Pension Schemes in Middle and Low Income Countries: Promises and Constraints. Chapter 12 in: R. Holzmann, and E. Palmer, eds., *Financial Defined Contribution (NDC) Pension Schemes: Concept, Issues, Implementation, Prospects* (The World Bank and Riksforsakrings Verket).

Müller, K., 2001a, Public-Private Interaction in the Structural Pension Reform in Eastern Europe and Latin America, *Insurance and Private Pensions Unit*, OECD.

Müller, K., 2001b, The Political Economy of Pension Reform in Eastern Europe, *International Social Security Review*, 2(54): 67-79.

Müller, K., 2003, The Making of Pension Privatization in Latin America and Eastern Europe in: R. Holzmann, M. Orenstein, and M. Rutkowski, eds., *Pension Reform in Europe: Process and Progress* (Washington DC: The World Bank).

Mulvey, J., and W. T. Ziemba, 1998, Asset and Liability Management Systems for Long-Term Investors: Discussion of the Issues, in: Ziemba, W., and J. Mulvey, eds., *Worldwide Asset and Liability Management* (Cambridge, United Kingdom: Cambridge University Press), pp. 3-38.

Palacios, R., and M. Pallarés, 2000, International Patterns of Pension Provision Social Protection Discussion Paper, No. 0009 (Washington DC: The World Bank).

Palmer, E., 2006, Conversions to NDC. Issues and Models. Chapter 9 in: R. Holzmann, and E. Palmer, eds., *Financial Defined Contribution (NDC) Pension Schemes: Concept, Issues, Implementation, Prospects* (The World Bank and Riksforsakrings Verket).

Queisser, M., 2000, Pension Reform and International Organizations: From Conflict to Convergence, *International Social Security Review*, 2(53): 31-45.

Schwarz, A. M., and A. Demirguc-Kunt, 1999, Taking Stock of Pension Reforms Around the World (Washington DC: The World Bank).

Settergren, O., 2001, The Automatic Balance Mechanism of the Swedish Pension System—A Non-Technical Introduction. Available at http:www.rfv.se/english.

Settergren, O., and B. Mikula, 2005, The Rate of Return of Pay As You Go Pension Systems. Chapter 7 in: R. Holzmann, and E. Palmer, eds., *Financial Defined Contribution (NDC) Pension Schemes: Concept, Issues, Implementation, Prospects* (The World Bank and Riksforsakrings Verket).

Social Security Administration, 1999, Social Security Programs Throughout the World. S.S.A.

Valdés-Prieto, S., 1998, Risks in Pensions and Annuities *Human Development Network Social Protection Group* (Washington DC: The World Bank).

Valdés-Prieto, S., 2000, The Financial Stability of Notional Account Pensions, *Scandinavian Journal of Economics*, 102(3): 395-417.

Valdés-Prieto, S., 2002, Políticas y mercados de pensiones, *Ediciones Universidad Católica de Chile,* Santiago de Chile.

Vidal-Meliá, C., and I. Domínguez-Fabián, 2004, The Spanish Pension System: Issues of Introducing Notional Defined Contribution Accounts. Chapter 23 in: R. Holzmann, and E. Palmer, eds., *Financial Defined Contribution (NDC) Pension Schemes: Concept, Issues, Implementation, Prospects* (The World Bank and Riksforsakrings Verket).

Williamson, J. B., 2004, Assessing the Pension Reform Potential of a Notional Defined Contribution Pillar, *International Social Security Review*, 57 (1): 47-64.