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Optimal funding of pension schemes

Pierre Plamondon
Coordinator for International Activities
and
Denis Latulippe
Chief Actuary
The Quebec Pensions Board
Canada

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Summary

How can social security organizations optimise pension financing under a changing demography and a volatile economy? This is a question of paramount importance in many countries, where social security schemes providing substantial benefits to retirees and financed on a pay-as-you-go (PAYG) basis are confronted with population ageing. It is often stated in the on-going debate on the reform of national pension systems that private fully-funded schemes are more adapted to the "new environment" and that, therefore, the role of public schemes should be limited to alleviate poverty. The capacity of the schemes financed on a PAYG basis to cope with the increasing pension costs resulting from the ageing of the population is a major argument in favour of such structural reforms.

This paper attempts to throw some light on the debate by providing simulation results on the sensitivity of alternative financing methods to a changing demographic environment and a volatile economic environment. In other words, it is argued that the need for contribution rate stability should not be addressed considering the demographic environment only, but also taking into account elements of the economic environment such as interest rates, wages and prices which have a determinant impact on pension financing. The paper reviews the objectives pursued in the selection of a financing system and the determinants of contribution rates. Information on the demographic and the economic characteristics of different countries are discussed and used as inputs for actuarial simulations. These simulations demonstrate that different financing methods react differently to different demographic and economic scenarios and that, generally speaking, a proper mix of PAYG and funded systems should prove to be an optimal system. An important conclusion, based on classical portfolio analysis, is that partial funding may represent an optimal approach for maximizing the revenue of the scheme in the long run.

Introduction

Most industrialized countries have developed social security schemes that provide substantial benefits to retirees and are generally financed on a pay-as-you-go (PAYG) or partial funding basis. Virtually all these countries will be facing an ageing of their population that will make necessary an increase of the contribution rate in order to ensure the financial viability of the schemes (assuming no reduction in benefits). Some developing countries have introduced similar pension schemes and will pass through a similar demographic transition as their economy develops. The pace of the demographic transition will be particularly fast in certain emerging market economies that are also characterized by high rates of economic growth.

It is often stated in the on-going debate on the reform of national pension systems that private fully-funded schemes are more adapted to the "new environment" and that, therefore, the role of public schemes should be limited to alleviate poverty (World Bank, 1994). The capacity of the schemes financed on a PAYG basis to cope with the increasing pension costs resulting from the ageing of the population is an argument used frequently to justify these structural reforms.

This paper aims at throwing light on the debate by providing simulation results on the sensitivity of alternative financing methods to a changing demographic environment and a volatile economic environment. In other words, it is argued that the need for contribution rate stability should not be addressed considering the demographic environment only, but also taking into account elements of the economic environment such as interest rates, wages and prices which have a determinant impact on pension financing.

The first section of the paper reviews the objectives pursued in the selection of a financing system. Information on the demographic and the economic characteristics of different countries, and in particular the situation in Quebec, will then be discussed and used as inputs for actuarial simulations. These simulations will demonstrate that different financing methods react differently to different demographic and economic scenarios and that, generally speaking, a proper mix of PAYG and funded systems should prove to be an optimal system. The question of optimization will also be looked at from an asset management perspective by using a financial model to demonstrate that a proper mix of PAYG and funded systems is also an efficient strategy from an asset management point of view.

1. Criteria for the choice of a financing system

The main purpose of a pension scheme is to provide a certain level of income replacement at retirement. The objective of pension financing is to allocate, in an orderly and rational manner, the cost of providing these pensions. It is necessary to determine at which pace the resources will be raised over the years (the financing system) and how the annual financial burden will be shared among the financiers of the scheme.

1.1. Contribution rate stability

A first criteria for the choice of a financing system is the stability of the contribution rate. Under the typical public pension scheme, the contribution rate will normally vary over the years in line with the development of expenditures, the need for reserve funds and the changes in the demographic and the economic environments. This is particularly true for defined-benefit schemes where the benefit amount is calculated at the time of retirement (based on plan provisions). Under a defined-benefit scheme, the contribution rate is the variable item and is determined so that sufficient funds are available to finance the intended pension level.

Nevertheless, the same logic may also apply to defined-contribution schemes because the effective contribution rate may have to be adjusted from time to time in order to provide a reasonable level of pension.
Under a public defined-benefit pension scheme, frequent revisions of the contribution rate may be necessary, especially in the years following the introduction of the scheme, in order:

- to avoid an excessive accumulation of reserve funds; and
- to keep the contribution rate at a low level in a period of economic difficulties or at an early stage of economic development.

Nevertheless, a stable contribution rate is generally considered desirable for the following reasons:

- to promote greater confidence in the scheme;
- to strengthen fiscal discipline (governance) via an early recognition of the long term financial implications of plan amendments (by modifying the contribution rate at the time of the introduction of the amendments);
- to reinforce the benefit/contribution link (assuming a stable benefit level);
- to distribute costs more equally across successive generations (especially in a context of population ageing).

The funding level required to achieve the objective of contribution rate stability generally depends on the maturity state of the scheme, the demographic characteristics of the population and the stage of development of the economy and of the financial markets.

1.2. Minimizing required contributions

The choice of a financing system should also aim at minimizing the overall amount of contributions necessary to finance the scheme during its existence. A higher level of funding would be sought where it is reasonable to expect that the rate of return on the scheme′s assets will be higher than the rate of increase of the wage base (combination of the rate of increase of the average wage and the rate of increase of the number of workers). In such a situation, the revenue generated by investment earnings will help reduce the need to raise contributions.

On the other hand, a reduced level of funding would be preferred in the context of under-developed capital markets with a limited capacity to absorb savings in an effective way. In the situation of low investment return and fast increasing wage base, PAYG appears to be a more efficient strategy.

1.3. Solvency and other criteria

The objectives of contribution rate stability and financial optimization are basic concerns in the choice of a financing system. There are however other objectives and constraints to pension financing, like the objective of solvency and some other objectives and constraints of a more intangible nature.

As regards solvency, the necessity to guarantee the payment of benefits is an important objective of pension financing. This is basically why occupational pension schemes (at least those established at the enterprise level) and individual savings schemes are normally fully-funded. However, social security pensions usually do not need to be fully-funded as they provide benefits according to laws and regulations and since the risk of insolvency, for a society as a whole, cannot be managed the same way as for an enterprise or an individual.

Among the criteria of a more intangible nature, there are the macroeconomic issues and more specifically the potential impact of social security on the economy. Although there is limited empirical evidence, it is often argued that PAYG social insurance schemes may impair economic growth because of the perverse effect on savings and the labour market. It is also argued that the development of private pension schemes fosters investments and the development of capital markets.

Some political issues should also be considered like the capacity of a public body to manage pension assets in an optimal way, free of any political interference, and the question of the supervision of the investment managers of private pension schemes.

The numerous publications on the economics of social security pensions are not reviewed or analyzed in this paper. The political issue will not be addressed either. It is dependant on the national context and is beyond the scope of this paper. The paper will rather focus on actuarial and financial considerations in the choice of a financing system.

2. Determinants of the contribution rate

2.1. Under PAYG

The PAYG rate is defined as the ratio of total schemes expenditure to total insured earnings. On the numerator side, the ratio is influenced by the level of benefits (the pension formula and the indexing mechanism) and the number of beneficiaries. The level of expenditure will normally increase during the years following the introduction of a pension scheme as the provisions gradually take their full effect and contributors acquire full entitlement to benefits. The denominator is influenced by the number of contributors and their average earnings.

A higher rate of growth of average earnings will result in lower PAYG rates. On the other hand, the PAYG rate will increase in a context of population ageing where the ratio between the number of beneficiaries and the number of contributors increases over time.

2.2. Under full-funding

For fully-funded schemes, the contribution rate at a given point in time is estimated based on the discounted value of future benefits. For defined-benefit schemes, the discounted value depends on the projected benefit payable and on assumptions relative to retirement, death and invalidity contingencies as well as on assumptions relative to the future development of interest rates, wages and prices. For defined-contribution scheme, the present value of future benefits is, by definition, equal to the value of accumulated contributions.

In the case of fully-funded defined-benefit schemes, the contribution rate has to be reviewed periodically to take into account deviations of the experience of the scheme from the actuarial assumptions. In fact, the contribution rate is quite sensitive to these deviations because the contribution rate is revised not only to properly reflect the cost of providing current benefits but also to readjust the funding of the scheme for the past service liabilities over a certain number of years. The past service liabilities and the assets accumulated under a fully-funded mature scheme amount to several years of contributions and therefore, the periodical revisions of the contribution rate necessary to maintain the funding objective of the scheme might result in important year-to-year variations.

In the case of defined-contribution schemes, "unforeseen developments" will impact the benefit level rather than the contribution rate, unless there are amendments to the provisions defining the contribution rate. However, the impact might be of a greater magnitude because defined-contribution schemes are funded on an individual basis and therefore, there is limited possibility to amortize the impact of the deviations over time (especially in the years preceding retirement) or to spread it across individuals.

Amounts accumulated in defined-contribution schemes at the time of retirement will be greatly influenced by the interest rate earned on the fund before retirement. Also, the level of interest rates at the time of conversion of the individual account into an annuity will affect the amount of the periodic pension.

3. The demographic and economic trends

Simulations of Section 4 will be based on assumptions inspired from the observed demographic and economic trends in countries of the Organization for Economic Cooperation and Development (OECD) with a particular focus on the Canadian experience. A summary description of those trends follows.

3.1. Demographic and labour market trends

The labour force (number of people available for work) has increased steadily in the developed countries over the last decades. In a sample of 18 OECD countries (see Table 1), the labour force has increased by 1.4 % per annum on average between 1970 and 1990. The increase is due to the arrival at working ages of the large generation born between 1950 and 1970. The increase also reflects the higher activity of women in the labour force. This trend was counter-balanced only partially by the tendency towards earlier retirement and a later entry in the labour force. On the other hand, what was observed in the 1990s is a lower increase of the labour force (0.9 % per annum on average) as compared to the previous periods. This reflects the arrival of the baby boom generation at ages where activity rates generally decrease. This trend will accelerate during the period 2000-2020.

Table 1. ***Average increase of the labour force in 18 selected OECD countries (1960-2000)***

Period	Average annual increase (%)
1960-1970	1.0
1970-1980	1.4
1980-1990	1,3
1990-2000	0.9

Source: OECD statistical base. The countries included in the sample are Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Luxembourg, New Zealand, Norway, Portugal, Spain, Switzerland, Turkey, United Kingdom and United States.

The number of people in the older age groups (age 65 and over) has increased faster than the active population in the last forty years. It increased by 2.1 % on average between 1950 and 1990. The number of retirees (inactive old people) increased still faster because of the gradual reduction of the effective age of withdrawal from the labour market. The average effective retirement age in OECD countries has decreased from 68 in 1950 to 62 in 1990.[1] Coupled with an increase of the life expectancy, the reduction of the effective retirement age has resulted in a significant increase of the duration of retirement (from eleven years in 1950 to seventeen years in 1990 on average for males in the OECD countries).[2] Accordingly, the average passivity ratio (duration of retirement as a ratio of the time spent in the labour market) for the OECD countries is estimated at 40 % for 1990. In the coming decades, the number of people in the older age groups will increase faster than the rest of the population, in the industrialized countries. This will be particularly important between 2010 and 2030 when the baby boom generation retires. For Canada, it is estimated that the passivity ratio will increase from 47 to

[1] See Latulippe, 1996.

[2] Ibid.

51 % between 2000 and 2050. For women, the ratio will increase from 66 to 71 % over the same period.

Another common measure, the old age dependency ratio, will increase significantly because of the move of the baby boomers into retirement.[3] In Quebec, for example, the old age dependency ratio will increase from 21.0 % in 2000 to 46.8 % in 2030, as shown in Table 2.

Table 2. ***Ratio of population aged 65 and over to population aged 20 to 64 (Quebec)***

Year	Ratio (%)
2000	21.0
2010	24.8
2020	34.4
2030	46.8
2040	48.2
2050	49.2

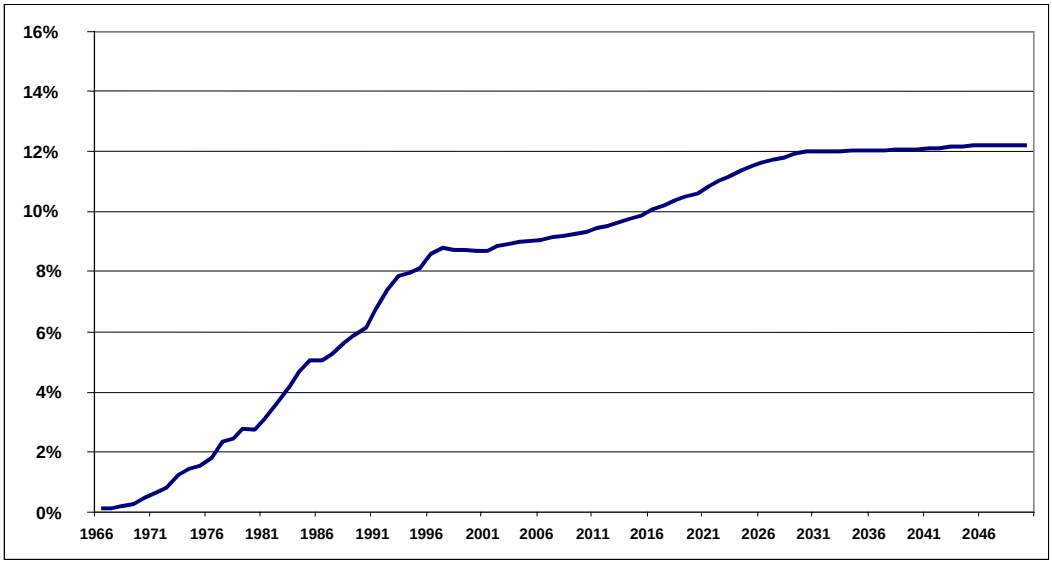
Other countries, especially the emerging markets of Eastern Asia characterized by high economic growth and a rapid decline of fertility rates, will also face a rapid ageing of their population in the future. For instance, in China, the old age dependency ratio was equal to 8.3 % in 1995 (and 6.8 % in 1950). It should be approximately equal to 24 % in 2050.[4]

Demographic developments are especially important for defined-benefit PAYG schemes. The cost of these schemes develops in line with the relative number of beneficiaries compared to the number of contributors. These schemes are therefore dependent on changes in both the annual number of new retirees and the duration of retirement (see Figure 1 for the evolution of the PAYG rate under the Quebec Pension Plan (QPP)). Under a defined-contribution scheme, an increase of the duration of retirement would result in a reduction of the pension.

[3] The passivity ratio compares the number of years spent in retirement to the number of years spent in the labour market. It is therefore not dependent on the total population structure (relative size of successive generations). The dependency ratio is dependent on the total population structure as it provides a relative measure of the number of old age people compared to the number of people in the working-age groups.

[4] Depending on the future progression of fertility rates and mortality rates the value of 24 % was obtained assuming a gradual rise of the total fertility rate from its current level of 1.9 to an ultimate level of 2.1 in 2050. By then, life expectancy was assumed equal to 75 years for males and 80 years for females (UN, 1996, medium-variant projection).

Figure 1. ***Past and projected PAYG rates under the Quebec Pension Plan (1966-2050)***



Fully-funded schemes are less sensitive to demographic changes. Nevertheless, significant demographic transformations may have an "indirect" impact on those schemes since the demographic environment may have impacts on the economy. For instance, increased saving by large cohorts of young people and liquidation of savings by large cohorts of old people could have an impact on the rate of return of pension funds.

3.2. Trends of economic variables

Economic variables affect pension systems in two respects. First, higher rates of economic growth make possible to pay higher pensions since pensions have to be paid out of total current income (from either wages or capital income), no matter how it is financed. Second, the contribution rate needed to finance pensions is recalculated periodically. Under certain financing systems, the re-determination of the contribution rate requires a reassessment of economic assumptions taking into account current economic conditions. Different financing systems react differently to different economic conditions.

This paper focuses on financing issues, considering historical data on interest rates and wage growth. For the purpose of the actuarial simulations of Section 4, different scenarios for the future development of interest rates and wages will be discussed.

Various comparisons have been made between the rate of return on pension portfolios and the rate of growth of average earnings. One of them (Thompson, 1998) compares the wage growth and interest rates over the period 1953-1995 (see Table 3). During the period 1953-1975, wages grew rapidly (except in the United States) and real interest rates were low. During

the period 1974-1995, the trend was reversed: wage growth decreased significantly and interest rates rose.

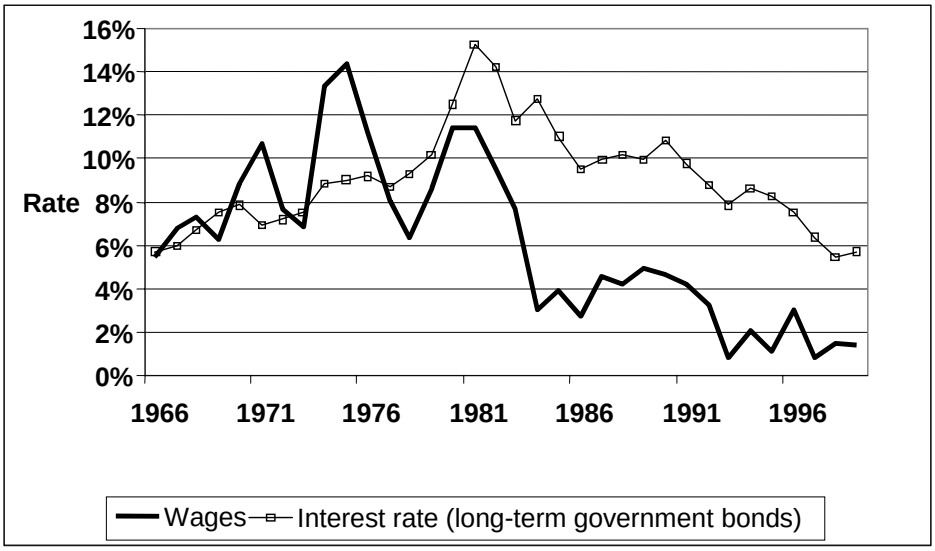
Table 3. ***Real wage growth and interest rates in four OECD countries (1953-1995)***

	Germany		Japan		United Kingdom		United States	
	Wage growth (%)	Interest rate (%)	Wage growth (%)	Interest rate (%)	Wage growth (%)	Interest rate (%)	Wage growth (%)	Interest rate (%)
1953-1973	7.1	3.8	8.5	4.6	5.4	1.7	2.2	0.3
1974-1995	2.6	4.0	1.8	3.0	1.8	1.9	- 0.1	4.1

Source: Thompson, L. 1998. *Older and wiser: The economics of public pensions*.

The situation in Canada has been similar, with wages growing rapidly before 1980 and slowing down relative to interest rates in recent years (see Figure 2).

Figure 2. ***Nominal wage growth and interest rates in Canada (1966-2000)***



Source: Canadian Institute of Actuaries, Report on Canadian Economic Statistics.

A study of the Canadian Institute of Actuaries[5] compares wage increases and interest rates during the 1960s and the 1990s. The study observes that during the 1960s, real wage increases and real interest rates were both approximately equal to 2 %. During the 1990s, the real wage increase decreased to 1 % while the real interest rate increased to 4 %. The economic environment of the 1960s was thus favouring PAYG financing but the environment of the 1990s encouraged a higher level of funding.

[5] Canadian Institute of Actuaries, Rapport du groupe de travail sur l'avenir du Régime de pensions du Canada/Régime de rentes du Québec.

3.3. Correlation between wages and interest rates

Table 4 shows correlation factors between wage increases and the rate of return on specific types of investments (stocks and bonds) in Canada for various periods. It shows that, over long periods, one variable that influences the growth of contribution income (wages) is negatively correlated with the rate of return on scheme's assets (stocks and bonds). This is a first indication that there may be an advantage in adopting a partial funding strategy under which the revenue of the scheme will be influenced by a mix of contribution revenue (depending on the wage bill) and investment income (depending on financial assets).

Table 4. ***Correlation between wage increases and the rate of return on stocks and bonds in Canada***

Period	Correlation coefficient between the variation of	
	Wage increase and return on stocks	Wage increase and return on bonds
1961-1970	- 0.11	0.17
1971-1980	- 0.36	0.15
1981-1990	- 0.13	0.00
1991-2000	- 0.30	0.12
Last 20 years	- 0.24	0.05
Last 30 years	- 0.11	- 0.23
Last 40 years	- 0.10	- 0.17

Source: Canadian Institute of Actuaries, *Report on Canadian Economic Statistics 1924-2001,* and authors' calculations.

4. Variability of the contribution rate under different financing options

This section present actuarial simulations to test the sensitivity of the contribution rate to different economic assumptions under different financing systems. The analysis is made using the financial projections of the QPP from the actuarial valuation as at 31 December 2000.

4.1. Characteristics of the scheme

The QPP has the following characteristics:

Type:	Defined-benefit
Year of introduction:	1966
Type of benefits:	Old age, invalidity and survivors pensions
Old age pension formula:	25 % of average earnings (for a full career)
Pension indexing:	100 % of consumer price index

The scheme is presently financed under a partial funding approach under which the contribution rate of 9.9 %, reached in 2003, is considered "permanent" as long as the reserve does not decrease below two times the annual outgo over the fifty-year period following the valuation date. According to the actuarial valuation as at 31 December 2000, the reserve in 2050 is projected to represent around three times the annual expenditure of the scheme if the contribution rate is left constant at 9.9 % after 2003.

4.2. Financing options

The following analysis considers three financing approaches to compare the effect of various scenarios as regards future rates of increase of earnings and rates of return on the scheme's assets. Contribution rates are determined for the years 2001 to 2050, using projection results of the 31 December 2000 actuarial valuation. Three financing options are considered:

1. *Pure PAYG system* (e.g. with no accumulation of reserve): the contribution rate is established such that contributions for a year are equal to the scheme's expenditure for that year. The initial reserve as of 31 December 2000 is supposed equal to zero.

2. *Partial funding*: the contribution rate is calculated as the constant rate applicable for the next fifty years such that the reserve at the end of fifty years is equal to three times the annual scheme's expenditure (the result of the last valuation of the QPP). The initial reserve as of 31 December 2000 is supposed equal to the actual reserve of the QPP as of that date.

3. *Full funding*: the contribution rate is determined as the constant contribution rate that would apply for the next fifty years such that the reserve ratio at the end of fifty years is equal to 25. The reserve ratio of 25 is estimated to be equivalent the present value of accrued benefits at a given date under the scheme.[6] We may consider here that the government would issue recognition bonds to the persons who contributed to the scheme before 31 December 2000 and that the new contribution rate would cover only the cost of rights credited after that date. The recognition bonds would accrue interest until retirement (or previous invalidity or death), at which time it would be converted into a pension.

We suppose, in our simulations, that the contribution rate is re-determined every five years. At each successive valuation, the projected data for the following fifty years is required for determining the contribution rate under the last two approaches (partial funding and full funding). For that reason, projected data until 2100 are necessary. It is assumed that the

[6] This value is equivalent to a proportion of the accrued liability of the Canada Pension Plan as determined in its 2000 actuarial report. The Canada Pension Plan is the equivalent of the QPP for the other Canada provinces.

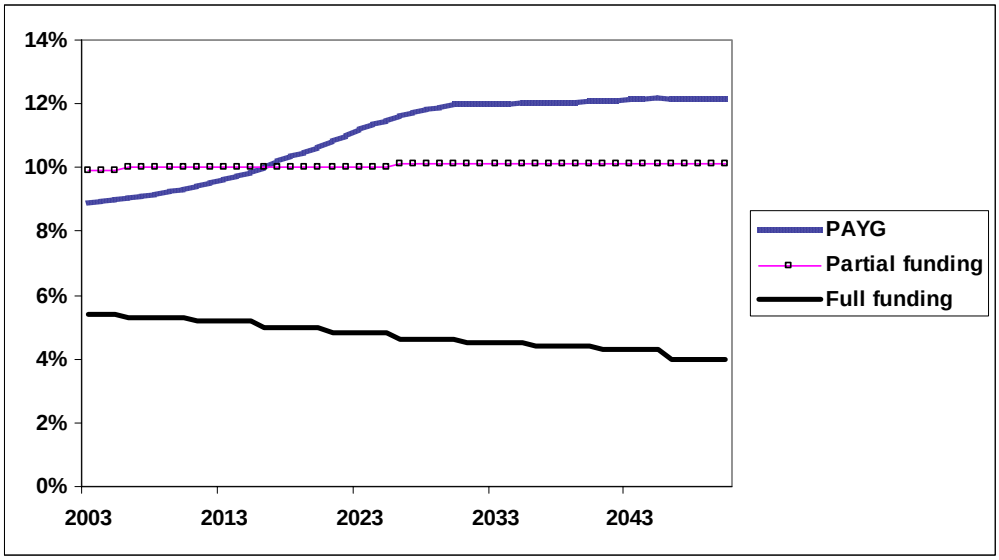
demographic and economic assumptions as regards the period following an actuarial valuation are not modified at each successive valuation.

4.3. Base scenario

Under the base scenario:

- The PAYG contribution rate increases gradually from 8.7 % in 2001 to 12.0 % in 2030 and stays around that level until 2050.
- Under the partial funding approach, the contribution rate increases slightly during the period from its present level of 9.9 % to 10.1 % in 2050;
- Under the full funding approach, the contribution rate decreases continuously over the next fifty years from its 2001 level of 5.4 % to an ultimate level of 4.0 % in 2050. The initial contribution rate decreases because the cost related to the past service of baby-boomers (the large liability of present contributors) is taken care separately by means of the recognition bonds. The cost decreases over time because of the increase of scheme's participation rates (particularly for women) that is assumed for the period 2001-2050 and that translates into a longer average period of contribution for the same level of pension.

Figure 3. ***Contribution rate under three financing options (base scenario)***



4.4. Sensitivity tests

Sensitivity of the contribution rate under the three financing options is measured for various scenarios of evolution of earnings increases and rates of return of the fund. Three scenarios are examined (see Table 5).

Table 5. *Three scenarios for economic variables (period 2001-2050)*

Period	Scenario 1 - Fluctuating rate of return	Scenario 2 - Fluctuating earnings increases	Scenario 3 - Fluctuating rate of return and fluctuating earnings increases	
	Difference with the base scenario as regards the rate of return of the fund	Difference with the base scenario as regards the rate of increase of earnings	Difference with the base scenario as regards the rate of return of the fund	Difference with the base scenario as regards the rate of increase of earnings
2001-2005	+ 5 %	+ 3 %	+ 5 %	– 3 %
2006-2010	– 5 %	– 3 %	– 5 %	+ 3 %
2011-2015	+ 5 %	+ 3 %	+ 5 %	– 3 %
2016-2020	– 5 %	– 3 %	– 5 %	+ 3 %
2021-2025	+ 5 %	+ 3 %	+ 5 %	– 3 %
2026-2030	– 5 %	– 3 %	– 5 %	+ 3 %
2031-2035	+ 5 %	+ 3 %	+ 5 %	– 3 %
2036-2040	– 5 %	– 3 %	– 5 %	+ 3 %
2041-2045	+ 5 %	+ 3 %	+ 5 %	– 3 %
2046-2050	– 5 %	– 3 %	– 5 %	+ 3 %

Under the first scenario, the rate of return of the fund fluctuates around the values retained for the base valuation. For a period of five consecutive years, it is 5 % higher than the base rate and for the following period of five years, it is 5 % lower. This may be interpreted as a standard deviation of the return of the fund equal to 5 %. This value reflects recent estimates of the projected variability of the QPP investment portfolio over a five-year horizon.

Under the second scenario, the rate of increase of earnings fluctuates similarly around the values of the base valuation. For five consecutive years, it is 3 % higher than the base rate and for the following period of five years, it is 3 % lower. This level reflects the standard deviation of the increase of the total contributory earnings under the QPP over the period 1985-2000.

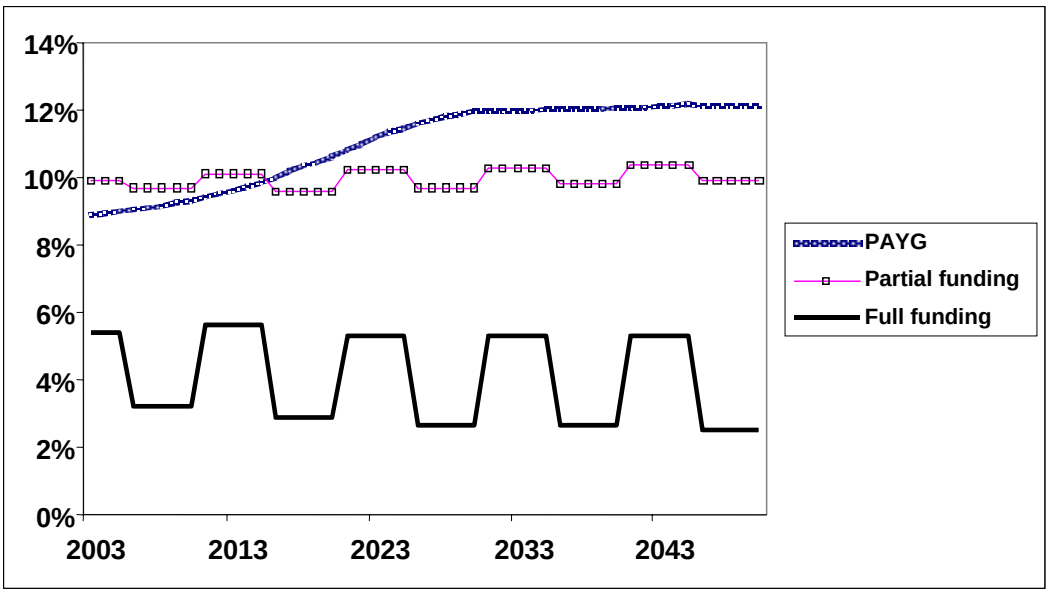
Under the third scenario, a fluctuating rate of return is combined with a fluctuating rate of increase of earnings.

In the following simulations and under the chosen financing systems, the re-determination of the contribution rate with a fifty-year funding objective is equivalent to amortizing gains or losses from experience over the fifty-year period following the actuarial valuation. This is coherent with the usual approach taken for the valuation of public pension schemes. Section 4.5 will perform a simulation using the financing methodology of a typical occupational pension plan with a faster amortization of surpluses and deficits.

Scenario 1 – Fluctuating rate of return

The PAYG contribution rate is not affected by fluctuations of the rate of return since no reserve is accumulated. Under partial funding, the reserve is low since its role is just to generate enough investment earnings to help contributions to face expenditures during the period of equilibrium. The contribution rate is thus affected only moderately by fluctuations of the rate of return. Under full funding, an important reserve is accumulated, so the contribution rate is directly affected by fluctuations of the rate of return. The timing of the increase or decrease of the contribution rate coincides with the timing of actuarial valuations, as shown in Figure 4.

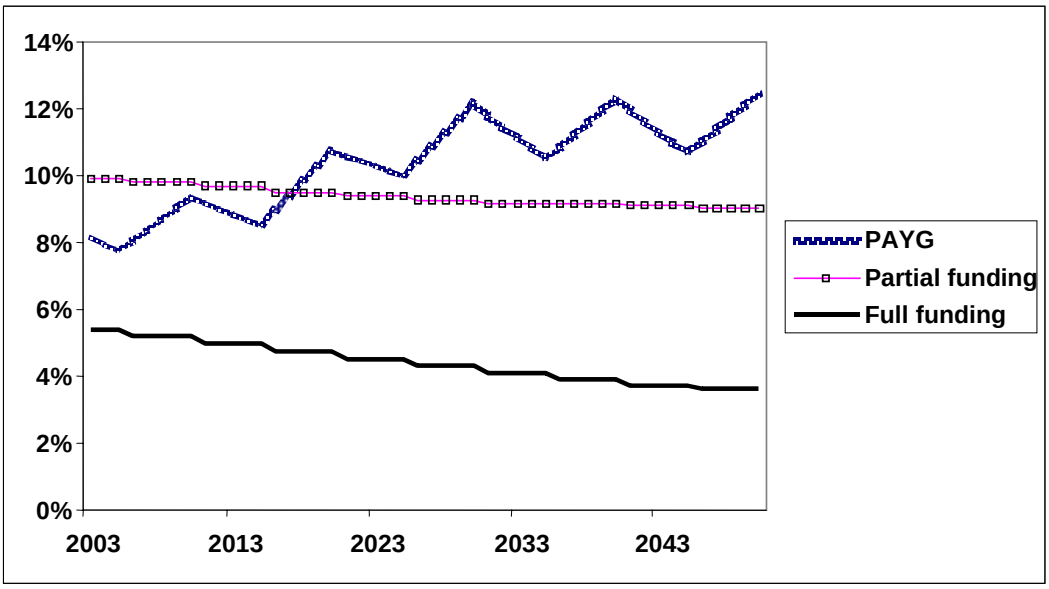
Figure 4. *Contribution rate under three financing options (scenario 1)*



Scenario 2 – Fluctuating earnings increases

Under the scenario of fluctuating earnings increases, the PAYG rate is directly affected because expenditures of a given year must be paid from current contributory earnings. Partial funding and full funding use fifty-year projections of revenue and expenditure to calculate the required contribution rate. The short-term experience gap is thus spread over the next fifty years and do not significantly affect the contribution rate. In addition, full funding relies mainly on its reserve for financing future expenditure, so the contribution rate is even less affected than partial funding by fluctuations of the earnings increases.

Figure 5. *Contribution rate under three financing options (scenario 2)*

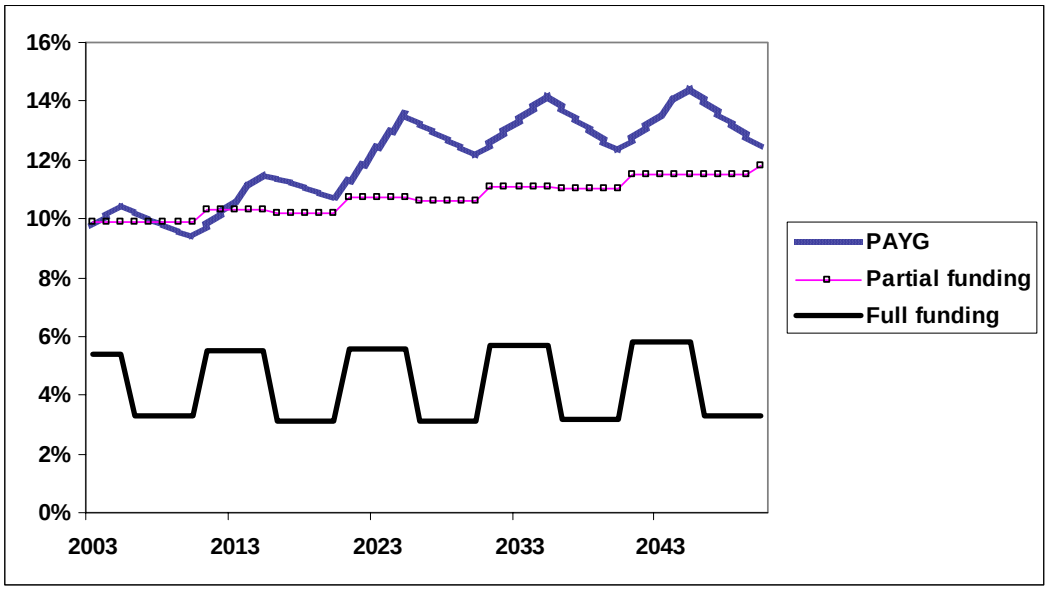


Scenario 3 – Fluctuating rate of return and fluctuating earnings increases

Scenario 3 combines the effects of scenarios 1 and 2. Partial funding appears to be more stable than the other two methods because its reserve is lower than in the case of full funding and the fact that it can spread over the next fifty years any experience variation (as compared with PAYG).

At first sight, we may think that even with a greater variability of the contribution rate, the full-funding approach leads to a contribution rate always lower than the other two approaches. It is important to note, however, that the contribution rate under the full-funding approach includes only part of the total cost of pensions. The government will eventually have to redeem the recognition bonds related to pension rights granted at the time of conversion of the scheme. He will then have to raise taxes to finance them, thus increasing the total burden imposed on workers and employers (who are the same entities that finance the public pension scheme).

Figure 6. *Contribution rate under three financing options (scenario 3)*

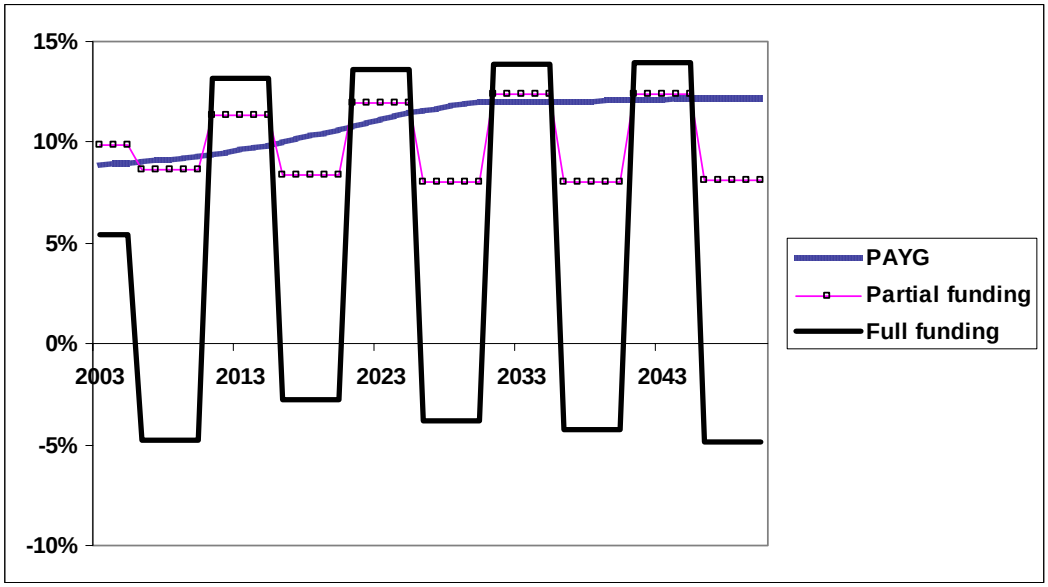


4.5. Faster amortization of gains or losses

The laws governing private pension plans usually call for the amortization of experience gains and losses over shorter periods than was is used in practice for public schemes. In Canada, for example, experience deficits must be amortized over the five-year period following the actuarial valuation.

We have performed a new simulation of scenario 1 (fluctuating interest rate) using that rule, assuming (as in the previous section) that the rate of return is 5 % lower than the base scenario for a five-year period, followed by an extra return of 5 % during the following period, etc. Results are illustrated in Figure 7.

Figure 7. ***Contribution rate under full-funding (fluctuating rate of return) and amortization of surplus/deficits over five years***



The amortization of surplus/deficits over five-year periods cause sharp variations of the contribution rate under the full funding approach, going from 5.4 % initially to -5 % following a period of high return, to 13 % following a period of low return. Variations are less important under partial funding due to the smaller size of the reserve and, as expected, the PAYG contribution rate experiences no variations.

This scenario could be associated with an environment of mandatory occupational schemes where all individual pension plans would have to meet short-term solvency tests and would be more affected by fluctuations of economic variables than a public scheme would be.

5. The financial point of view

Actuarial simulations were performed in Section 4 to assess the contribution rate stability of alternative financing options. However, the stability is not the only factor to consider in assessing different financing options. A financing strategy is generally considered efficient if it maximizes the expected return for a given level of risk (or alternatively, if it minimizes the level of risk for an expected level of return).

It is possible to assess the financial efficiency of different investment portfolios using classical financial models. Ideally, we would like to demonstrate that a financing strategy of partial funding, which was seen in Section 4.4 to guarantee a greater contribution rate stability, is efficient from a financial point of view.

For that purpose, we first recall that the revenue of a pension scheme comes from two main sources: contribution revenue (related to the level of the total contributory earnings) and investment earnings (affected by the rate of return on each type of asset). Hence the idea is to show that partial funding may be interpreted as investing in two main types of "securities": financial assets on one side (stocks, bonds, etc.) and total contributory earnings on the other side. If we can show that theses two variables (increase of the total contributory earnings and rate of return on investments) are negatively correlated (as Section 3.3 has attempted to demonstrate), then partial funding represents a way to diversify the scheme's revenue base, thus immunizing the scheme from variations in any of these factors.

Classical portfolio theory (Capital Asset Pricing Model) suggests that an optimal portfolio of securities may be calculated using past observed data on average return, standard deviation of returns and covariance between the return of the various securities. We have applied that theory using two securities in our "pension portfolio":

- Security A: a security having the same historical rate of return as a portfolio composed of 50 % of common stocks and 50 % of long-term bonds in Canada.
- Security B: a security having an historical return equal to the increase of the average wage in Canada. We suppose here that the future contributory base (in Quebec) will be mostly affected by the increase of the average base and not by the number of workers. In fact, given the future demographic developments in Quebec, the total number of employed persons is not expected to increase significantly in the next decades.

The returns on these two securities have been observed for various periods over the last fifty years and the average, standard deviation and covariance of the two securities for those periods appear in Table 6.

Table 6. ***Average nominal return and standard deviation of return for two hypothetical securities***

Period	Security A (stocks and bonds)		Security B (wages)		Covariance
	Average	Standard deviation	Average	Standard deviation	
1951-1960	6.7	8.9	5.0	2.1	- 1.9
1961-1970	7.3	8.0	5.5	2.2	- 0.3
1971-1980	9.8	9.9	9.9	2.8	- 7.6
1981-1990	11.2	11.8	5.7	2.9	- 2.6
1991-2000	13.4	9.5	2.1	1.1	- 1.3
1971-2000 (30 years)	11.4	10.2	5.9	4.0	- 8.4
1951-2000 (50 years)	9.7	9.6	5.6	3.3	- 4.8

It can be observed from Table 6 that the increase of wages (Security B) was very fast during the 1970s in Canada as compared to the other periods. On the other hand, the average return of our hypothetical asset portfolio (Security A) has continuously increased over the last fifty years. Table 6 also shows that the standard deviation was significantly larger for financial assets as compared to wage increases.

If we consider also the fact that the labour force increased at a fast rate during the 1960s and the 1970s, in addition to the fast increase of wages, it appears that a lower level of funding has been beneficial to the QPP during that period. The subsequent increase of rates of return and lower wage increases in the 1980s and 1990s were arguments for increasing the level of funding.

5.1. Application of the portfolio theory

Under the Capital Asset Pricing Model (CAPM), the optimal risky portfolio may be calculated using the following formula:

$$w_A = \frac{[E(r_A) - r_f]\sigma^2_B - [E(r_B) - r_f]Cov(r_A,r_B)}{[E(r_A) - r_f]\sigma^2_B + [E(r_B) - r_f]\sigma^2_A - [E(r_A) - r_f + E(r_B) - r_f]Cov(r_A,r_B)} \quad \text{(Formula 1)}$$

$$w_B = 1 - w_A$$

where:

w_A = Weight of security A in the portfolio
$E(r_A)$ = Average return of security A
r_f = Risk-free rate
σ^2_A = Variance of return of security A
$Cov(r_A,r_B)$ = Covariance of returns of security A and security B

The risk-free rate is generally defined as the interest rate on ninety-days Treasury bills. In Canada, the risk-free rate has been higher than the rate of increase of the wage base during certain periods in the past. However, interest rates have decreased significantly over recent years. To avoid mathematical inconsistency in the application of Formula 1, we will assume, in the following discussion, that the risk-free rate is equal to the rate of increase of wages.

Table 7. *Interest rate on ninety-days Treasury bills in Canada (1951-2002)*

Period	Interest rate (%)
1951-1960	2,4
1961-1970	4.9
1971-1980	8.1
1981-1990	12.2
1991-2000	5.7
2001	4.1
2002	2.6

Now what about the ideal level of funding for the future of the QPP? Using the long-term economic assumptions of the actuarial valuation of the QPP as at 31 December 2000 and Formula 1, Table 8 presents the optimal risky portfolio according to the CAPM under various assumptions regarding standard deviation and covariance of wage increases and rates of return. It shows the optimal portfolio distribution between "wage bill" and "financial assets".

Some of these scenarios were built from past experience data and others reflect expectations for the future based on theoretical analysis. For example, the investment manager of the QPP projects the average return of the target portfolio at 7.1 % for the period 2003-2012, with a standard deviation of 3.5 % (which has been retained for scenarios A, E and I). On the other hand, the standard deviation of the rate of return on QPP assets for the last thirty years was around 10 % (scenario M). Past experience also reveals that the standard deviation of the increase of the wage base is lower than the standard deviation of the rate of return of the fund (see Table 6).

The result of the application of Formula 1 would call for an approximately equal proportion of the portfolio invested in both securities, assuming that the standard deviation of the rate of return is at least equal to 3.5 % (which is plausible on the basis of historical data). Results presented in Table 8 thus supports the partial funding approach.

Table 8. ***Optimal distribution of sources of revenue for the QPP (from the financial point of view)***

	Average annual increase[a]	Scenario	Standard deviation												
			A	B	C	D	E	F	G	H	I	J	K	L	M
Wages	3.9		2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	3.0	3.0	3.0	3.0	3.0[c]
Assets	7.4		3.5[f]	4.0	4.5	5.0	3.5[f]	4.0	4.5	5.0	3.5[f]	4.0	4.5	5.0	10.0[d]
Covariance			-3.5	-4.0	-4.5	-5.0	-4.4	-5.0	-5.6	-6.3	-5.3	-6.0	-6.8	-7.5[e]	-15.0
Resulting weights[b]															
	Wages		0.47	0.50	0.53	0.56	0.41	0.44	0.47	0.50	0.37	0.40	0.43	0.45	0.63
	Assets		0.53	0.50	0.47	0.44	0.59	0.56	0.53	0.50	0.63	0.60	0.57	0.55	0.37

[a] Long-term economic assumptions of the QPP actuarial report as of 31 December 2000.
[b] Assumes a risk-free rate of 3.9 %.
[c] Reflects the experience of the period 1991-2000 under the QPP.
[d] Reflects the experience of the QPP for the period 1966-2001.
[e] Reflects the experience of the QPP for the period 1971-2000.
[f] Estimate of the Quebec Deposits and Investment Fund (*Caisse de dépôt et placement du Québec*) for the period 2003-2012 for the target portfolio.

Now let us look at the projected distribution of the two revenue bases (the wage bill and the scheme's reserve) for the QPP. Table 9 presents these two revenue bases for the next fifty years. In the future, total contributory earnings (the wage bill) will represent approximately 70 % of the total base on which revenues will be generated for the scheme, and the reserve will represent approximately 30 %.

Table 9. ***Comparison of total contributory earnings and reserve of the QPP in the future (figures in million CAD*)***

Year	Total contributory earnings	Reserve	Ratio of contributory earnings to the total	Ratio of the reserve to the total
2010	106,919	40,663	72 %	28 %
2020	162,061	81,907	66 %	34 %
2030	232,869	122,240	66 %	34 %
2040	340,838	160,781	68 %	32 %
2050	491,111	191,940	72 %	28 %

The fast increase of the contribution rate since 1998 to reach a "permanent" rate of 9.9 % from 2003 onwards puts the QPP in a good position as regards the composition of its revenue for the future. It has increased the level of funding of the QPP, while at the same time leaving enough space to revenues coming from contributions to approach values suggested by the optimal portfolio theory.

In the past thirty years in Canada, the standard deviation of wage increases has been greater than 2.0 % and greater than 5.0 % for the rate of return. Results presented in Table 8 show that an increase of the variability of the return of financial assets (stocks and bonds) would favour a lower level of funding, calling for a higher weight of revenues coming from contributions. According to the portfolio theory, the QPP should not increase significantly its level of funding in the future, except if it can be expected that the standard deviation of the economic variables will be lower than what appears in Table 8.

Conclusion

The paper has shown that the contribution rate of a pension scheme may be very sensitive not only to demographic changes, but also to a change in the economic environment. Fully funded schemes are more affected by the volatility of economic variables than are schemes financed on a PAYG or partially funded basis. The financing approach pursued by public pension systems allow them to amortize any difference between the experience and the previous economic assumptions over long periods, thus avoiding sharp movements of the contribution rate. The situation is not the same for private pension plans which must

* CAD = Canadian dollar.

normally amortize experience surpluses and deficits over short periods and are thus more sensitive to fluctuations of the rate of return or wage increases.

The paper also attempted to demonstrate that a proper mix of PAYG and funded systems is an appropriate approach for the financing of a national pension system, which may be composed of a combination of public and private pension schemes. Classical portfolio analysis applied to the economic variables influencing a typical pension scheme suggests that partial funding may also represent an optimal approach for maximizing the revenue of the scheme in the long run.

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