AUSTRALIAN SCHOOL OF BUSINESS ™

THE UNIVERSITY OF NEW SOUTH WALES

www.business.unsw.edu.au

School of Economics
Australian School of Business
UNSW Sydney NSW 2052 Australia

http://www.economics.unsw.edu.au

Public Sector Pension Policies and Capital Accumulation in Emerging Economies

Gerhard Glomm, Juergen Jung, Changmin Lee, Chung Tran

School of Economics Discussion Paper: 2009/10

ISSN 1323-8949

ISBN 978 0 7334 2791-6

Public Sector Pension Policies and Capital Accumulation in Emerging Economies*

Gerhard Glomm† Juergen Jung‡ Changmin Lee§ Chung Tran¶

7th May 2009

Abstract

In many emerging economies pension programs of public sector workers are more generous than pension programs of private sector workers. In this paper we investigate public pension reforms that improve efficiency and welfare by reallocating government resources from non-productive public pensions to productive public education and infrastructure investments. We argue that the opportunity costs of running generous public pension schemes for civil servants are potentially large in emerging economies that often suffer from low public investments in education and infrastructure. In addition, we quantitfy the savings distortions as well as the tax distortions from running a generous public pension program. Calculating transitions to the post-reform steady state, we find that welfare losses for the generation born before the reform are offset by welfare gains by the generations born after the reform.

JEL Classification: E62, H41, H55

Keywords: Social Security Reform, Generous Public Sector Pensions, Capital Accumulation, Public Education and Infrastructure Investments

*We would like to thank participants of the CESifo Conference on Pension Reform in Copenhagen, especially Alexander Kemnitz, Michele Boldrin and Harrie Verbon for helpful comments.

†Corresponding Author: Gerhard Glomm, Department of Economics, Wylie Hall, Indiana University, Bloomington, IN, 47405, phone: (812) 855-7256, e-mail: gglomm@indiana.edu

‡Department of Economics, Towson University. Contact: jjung@towson.edu

§Department of Economics, Indiana University, Bloomington. Contact: cl3@indiana.edu

¶School of Economics, University of New South Wales, Sydney, Australia. Contact: chung.tran@unsw.edu.au

1 Introduction

Pension programs for civil servants are on average more generous than pension programs for private sector workers. This is true for OECD countries as well as for emerging economies and developing countries. Palacios and Whitehouse (2006) report that OECD countries spend on average one quarter of total pension payments on public sector retirees, whereas in developing countries this share is much larger. Pension replacement rates for public sector workers tend to be considerable larger than the national average (see Table 2 in Palacios and Whitehouse (2006)). According to a recent OECD report on Brazil, for instance, public spending on pensions accounts for over 10 percent of GDP, a higher share than in the average OECD country, despite Brazil's younger population (OECD (2005)). A large share (almost one half) goes to public sector retirees (Souza et al. (2004)).

In the presence of population aging the generous public pension policy seems problematic as it puts a heavy burden on the budget of any economy. This is especially true for emerging economies where the tax base is smaller and generous pension programs divert much needed resources away from alternative uses like infrastructure investments or public education.

There is very little justification for running two separate pension schemes simultaneously. The argument that pension programs for civil servants have to be more generous in order to compensate civil servants for lower public wages only holds partly for emerging economies. There is evidence that the wage level in the public sector is typically higher than in the private sector (e.g. Foguel et al. (2000), Panizza (2000), Panizza (2001), and Panizza and Qiang (2005)). If on top of that public pension programs are more generous than private pension programs, equity issues will arise, in addition to concerns about economic sustainability in countries with a high income concentration and the beginnings of population aging. Surprisingly, there have been very few studies written on the reforms of sector specific pension programs, such as pension programs for public sector workers, compared to the voluminous literature on national pension programs.

In this paper we study the adverse effects of generous pension policies for public sector workers. We identify at least three channels through which generous pensions to civil servants distort the economy. First, generous pensions crowd out civil servants' savings and therefore the accumulation of capital stock. Second, generous public pension schemes are costly to finance with taxes that distort the intertemporal consumption and savings decisions of the households. Third, the forgone opportunities of investing these resources into other productive government activities can be substantial, especially in developing countries. The effects from the first two channels have been well documented in the literature on social security (e.g. see Diamond (1965) and Auerbach and Kotlikoff (1987)). However, this literature concentrates on national social security systems. Few papers investigate sector specific social security reform assuming that the small number of public sector retirees would only

allow for small post reform effects. Glomm, Jung and Tran (2006) show that these adverse effects are substantial but concentrate on early retirement issues. In this paper we therefore concentrate on exploring the effects of the third channel, alternative investments, while also taking capital accumulation effects into account. We think that the previous literature has understated the efficiency gains from public policy reform by ignoring the alternative usage of the freed up resources for investments into infrastructure and public education.

Analyzing the economic effects of generous public sector pensions requires a fully specified dynamic general equilibrium model in which recipients of public sector pensions, civil servants, play a meaningful economic role. We employ one such model in which civil servants work in two sub-sectors, public education and public provision of infrastructure. This set-up allows us to not only study the costs of public sector compensation including pension benefits but also the benefits of public sector employment. In addition, the government invests in a public capital to provide services to firms. These services are made available free of charge. We can think of these as being services flowing from the stock of roads and highways. The government also finances public expenditures on education and social security payments to private sector workers. In our model financing generous public sector pensions implies opportunity costs of lower expenditures on public education and/or infrastructure.

In order to obtain quantitative results we calibrate the model to Brazil where the public pension system is unusually generous. In the policy experiments conducted we first focus on steady state outcomes and then compute transitions. Our goal is to investigate alternative mechanisms to improve efficiency and welfare by reallocating government funds from non-productive public pensions to productive public education and infrastructure investments. In order to isolate the effects of public pension reform we conduct several policy experiments. First, we investigate the general equilibrium effects on the intertemporal consumption-savings decision and then on capital accumulation as a whole while cutting the generosity of public pension system and letting government consumption adjust to clear government budget constraints. With this policy experiment we can isolate the pure crowding out effects of public pension programs on private savings. Then, we let taxes adjust to clear government budget constraints which allows us to quantify the effects from removing distortions of tax-financing instruments. Finally, we analyze the opportunity costs of generous public pensions by investing freed up resources into public education and infrastructure while keeping taxes constant.

We find that the direct effects of public pension reform on civil servants's savings are relatively small because the public sector agents only make up a small fraction of the labor force. However, the total savings effects are large. The intuition is that the general equilibrium interest rates passes the saving effects of the reforms on to private sector agents. Besides, we find that the effects of the pension reforms can be much larger, when the pension reform is used to remove tax distortions from the labor markets. Finally, we find that

using the resources that become available from the reduction in public pensions payments on public investment in infrastructure or on public education has large effects on output and welfare. We also conduct sensitivity analysis and find that our results are robust to changes in parameter values.

The adverse effects of public pensions via forgone investment opportunities for other productive government activities are neglected in the previous literature on social security. Our key contribution is to highlight that these effects are potentially large. In addition, our positive analysis could be used as an important justification for reforming public pension systems in developing countries with low levels of public investments.

The following section describes the model and the definition of the competitive equilibrium. In section 3 we calibrate the model to Brazil and in section 4 we conduct policy experiments and discuss the results. Section 6 concludes. The Appendix contains all tables and figures.[1]

2 The Model

2.1 Environment

There is a large number of individuals who live for two periods in an overlapping generation set-up. Each period accounts for roughly 30 years. For reasons of simplicity we abstract from population growth and normalize the size of the population to one. A fraction N^p of the population is working in the private sector. The fraction of civil servants is denoted N^g. Workers who work in the public sector but do not have the status of a civil servant are counted as private sector workers. Only civil servants have access to generous pension payments. We therefore get

$$N^p + N^g = 1.$$

We distinguish two groups among civil servants. A fraction N^{ge} of civil servants is working in the public education sector, the others N^{gi} are working in the "public infrastructure"sector. We use the following notation

$$\begin{aligned} N^{ge} &= aN^g, \\ N^{gi} &= (1-a)\,N^g. \end{aligned}$$

All civil servants have an identical wage and pension scheme regardless of sector of employment. This scheme differs from private sector workers in contribution rates and also in

[1] We present the model solution method and additional figures in the Technical Appendix of the paper that is available on the authors' website at:
http://pages.towson.edu/jjung/Brazil1TecApp.pdf

benefit payments.

Agents value two different types of goods, a privately provided good and a publicly provided good. The utility preference of a member of generation t is

$$u\left(c_t, c_{t+1}\right) = \frac{1}{1-\sigma} c_t^{1-\sigma} + \pi\beta \frac{1}{1-\sigma} c_{t+1}^{1-\sigma},$$

where $\sigma, \beta > 0$, c_t, c_{t+1} is consumption in period t and $t+1$, π is an exogenous survival probability, β is the time discount factor, and σ is the inverse of the intertemporal elasticity of substitution.

The privately supplied good is produced from three inputs, the publicly provided service G_t, the private capital stock K_t, and effective labor (human capital) in the private sector H_t^p according to the production function

$$Y_t = A G_t^{\alpha_1} K_t^{\alpha_2} \left(H_t^p\right)^{\alpha_3},$$

where $\alpha_i \in (0,1)$ for $i = 1,2,3$, $\alpha_2 + \alpha_3 = 1$, and $A > 0$. Capital K depreciates at rate δ each period. The public good G is provided for free by the government. We think of this good as roads, highways or other elements of core infrastructure which is made available to all households and firms at a zero price. Firms only hire capital and labor. The condition $\alpha_2 + \alpha_3 = 1$ then ensures constant returns to scale in the two hired factors and zero profits. This kind of production function is standard and has been used by Barro (1990), Glomm and Ravikumar (1994), Turnovsky and Fisher (1995), Cassou and Lansing (1998) and many others.

Human capital is produced according to

$$h_{t+1} = D\left[\left(H_t^{ge}\right)^{\eta_1} + \chi_1 E_t^{\eta_1}\right]^{\frac{\gamma_1}{\eta_1}} h_t^{\gamma_2}, \tag{1}$$

where H_t^{ge} is public educational human capital (teachers), E_t is public education expenditure, h_t is the parental human capital, $D > 0$, $\eta_1 \leq 1$, $\chi_1 > 0$, $(\gamma_1, \gamma_2) \in (0,1)$, and $\gamma_1 + \gamma_2 \leq 1$.

Most models of human capital accumulation such as Loury (1981), Benabou (1996), Fernandez and Rogerson (1998) or Blankenau and Simpson (2004) only allow for one public input into human capital production. Here we find it useful to disaggregate public education inputs into teachers H_t^{ge} and material inputs E_t such as textbooks, computers and buildings.

The government uses effective labor (human capital) of civil servants employed in the non-educational sector $H_t^{ui} = H_t N_t^{ui} = H_t\left(1-a\right) N_t^g$ and public capital K_t^G to produce the public good according to

$$G_t = Z\left[\left(K_t^G\right)^{\eta_2} + \chi_2\left(H_t^{ui}\right)^{\eta_2}\right]^{1/\eta_2}, \tag{2}$$

where $Z > 0$, $\chi_2 > 0$, and $\eta_2 \leq 1$. Public capital evolves according to

$$K_{t+1}^G = (1 - \delta_G) K_t^G + I_t^G. \tag{3}$$

Public pensions are indexed to this period's public sector wages, where $w_t^g H_t$ is an individual public employee's wage income. The total wage bill of the public sector in a given period is $w_t^g H_t N_t^g$. Since $w_t^g H_t$ is the average wage of an individual agent in a period (which is roughly 30 years long), the question arises what fraction of this current wage is paid out to retirees. In order to capture different levels of generosity of a pension system we express the amount of pensions paid to public sector retirees as

$$T_t^g = \pi \Psi^g w_t^g H_t N_{t-1}^g, \tag{4}$$

where $\Psi^g > 0$. The larger Ψ^g becomes the more generous the public pension system becomes. In order to calculate the total amount of public pensions paid to retired civil servants we multiply the individual wage of a current civil servant $w_t^g H_t$ by the number of public sector retirees (the public employees of the previous period) N_{t-1}^g and by the generosity factor Ψ^g.

In period t the government faces the following expenditures (where we will express expenditures for government program i as fixed share $\Delta_{i,t}$ of output Y_t):

1. public education expenditures
$$E_t = \Delta_{E,t} Y_t, \tag{5}$$

2. investments in public capital
$$I_t^G = \Delta_{G,t} Y_t, \tag{6}$$

3. government consumption
$$C_{g,t} = \Delta_{C_g,t} Y_t,$$

4. pension payments to the old who were employed in the private sector
$$T_t^p = \pi \Psi^p w_t^p H_t N_{t-1}^p = \Delta_{T^p,t} Y_t, \tag{7}$$

5. wage payments to current civil servants $w_t^g H_t N_t^g$,

6. pensions to retired civil servants $\pi \Psi^g w_t^g H_t N_{t-1}^g$,

7. payments of public debt $\left(1 + r_t^b\right) B_t$.

The government collects two kinds of labor income taxes in the public sector, the standard tax on labor income τ_{Lt}^{g} and an additional social security tax τ_{Lt}^{ssg}. Workers in the private sector pay similar labor tax rates denoted τ_{Lt}^{p} and τ_{Lt}^{ssp}. In addition, capital income is taxed at rate τ_{Kt}. The stock of debt that the government can issue in period t is B_t. The government collects all accidental bequests from the deceased households. The government budget constraint can be written as

$$\begin{aligned}
&\left(1+r_t^b\right)B_t + \Delta_{E,t}Y_t + \Delta_{G,t}Y_t + \Delta_{C_g,t}Y_t + \overbrace{\pi\Psi^p w_t^p H_t N_{t-1}^p}^{\text{private pension } T^p} + \overbrace{w_t^g H_t N_t^g}^{\text{public wages}} + \overbrace{\pi\Psi^g w_t^g H_t N_{t-1}^g}^{\text{public pension } T^g} \\
&= B_{t+1} + \left(\tau_{L,t}^{ssg} + \tau_{L,t}^{g}\right) w_t^g H_t N_t^g + \left(\tau_{L,t}^{ssp} + \tau_{L,t}^{sspf} + \tau_{L,t}^{p}\right) w_t^p H_t N_t^p \\
&+\tau_{K,t} q_t K_t + \overbrace{(1-\pi)\, R_t K_t}^{\text{Accidental Bequests}},
\end{aligned} \tag{8}$$

where τ_{Lt}^{g} and $\tau_{L,t}^{p}$ are labor taxes in the public and private sector respectively, $\tau_{L,t}^{ssg}$ and $\tau_{L,t}^{ssp}$ are payroll taxes for social security, $\tau_{L,t}^{sspf}$ is the employer (firm) contribution to social security in the private sector, $\tau_{K,t}$ is the capital tax, $\Delta_{E,t}$ is the fraction of GDP spent on public education, $\Delta_{G,t}$ is the fraction of GDP spent on increasing the public capital stock, $\Delta_{C_g,t}$ is the fraction of GDP consumed by the government, $\Delta_{T,t}$ is the fraction of GDP that goes to retired private sector employees, Ψ^g is the parameter of generosity of the public sector pension system, and the last term are accidental bequests that are collected by the government. We assume that government behavior is exogenous.

2.2 Household Problem

We can now state the household problem as

$$\max_{c_t^j, c_{t+1}^j, i_{t+1}^j} \left\{ \frac{1}{1-\sigma}\left(c_t^j\right)^{1-\sigma} + (\pi\beta)\frac{1}{1-\sigma}\left(c_{t+1}^j\right)^{1-\sigma} \right\} \tag{9}$$

$$s.t.$$

$$\begin{aligned}
c_t^j + i_t^j &\leq \left(1-\tau_{Lt}^{ssj} - \tau_{Lt}^{j}\right) w_t^j h_t \\
c_{t+1}^j &\leq R_{t+1} i_t^j + T_{t+1}^j / N_t^j
\end{aligned} \tag{10}$$

where, $j = g$ if it is a public sector worker, $j = p$ if it is a private sector worker, $i_t = k_{t+1} + b_{t+1}$ is the agent's savings in form of physical capital or government bonds, R_{t+1} is the gross rate

of return on investments, and $T_{t+1}^{j}$is a government transfer received when old.[2] Household j takes all tax rates and prices as given. Accidental bequests due to the exogenous survival probability will be collected by the government.

2.3 Firm Problem

The firm's problem is standard. Note, however, that the firm takes the level of the public good as given so that the firm only chooses to hire physical capital and human capital. Note also that the government collects a social security tax from the firm at the rate τ_t^{sspf}. Thus the firm's problem is

$$\max_{\left(H_t^p, K_t\right)} F\left(G_t, K_t, H_t^p\right) - \left(1+\tau_t^{sspf}\right) w_t^p H_t^p - q_t K_t,$$

given $\left(G_t, \tau_t^{sspf}, w_t^p, q_t\right)$.

2.4 Definition of Equilibrium

Given the government policy $\left\{\tau_{Lt}^p, \tau_{Lt}^g, \tau_{Lt}^{ssp}, \tau_{Lt}^{ssg}, \tau_{Lt}^{sspf}, \tau_{Kt}, \Delta_{E,t}, \Delta_{K^G,t}, \Delta_{C_g,t}, \Delta_{T,t}, w_t^g, N_t^g, \Psi^g, \Psi^p\right\}_{t=0}^{\infty}$, a competitive equilibrium is a collection of sequences of decisions of privately employed households $\left\{c_t^p, c_{t+1}^p, k_{t+1}^p, b_{t+1}^p, h_{t+1}^p\right\}_{t=0}^{\infty}$, sequences of decisions of publicly employed households $\left\{c_t^g, c_{t+1}^g, k_{t+1}^g, b_{t+1}^g, h_{t+1}^g\right\}_{t=0}^{\infty}$, sequences of aggregate stocks of private physical capital and private human capital $\left\{K_t, H_t^p\right\}_{t=0}^{\infty}$, sequences of aggregate stocks of public physical capital and public human capital $\left\{K_t^G, H_t^g\right\}_{t=0}^{\infty}$, sequences of factor prices $\left\{w_t^p, q_t, r_t^b\right\}_{t=0}^{\infty}$ such that

(i) the sequence $\left\{c_t^p, c_{t+1}^p, k_{t+1}^p, b_{t+1}^p, h_{t+1}^p\right\}_{t=0}^{\infty}$ solves the maximization problem of the privately employed household (9) with $j=p$ and the sequence $\left\{c_t^g, c_{t+1}^g, k_{t+1}^g, b_{t+1}^g, h_{t+1}^g\right\}_{t=0}^{\infty}$ solves the maximization problem of the publicly employed household (9) with $j=g$;

(ii) factor prices are determined by

$$q_t = \alpha_2 \frac{Y_t}{K_t}, \tag{11}$$

$$w_t^p = \frac{\alpha_3}{\left(1+\tau_t^{sspf}\right)} \frac{Y_t}{H_t^p} = \frac{\alpha_3}{\left(1+\tau_t^{sspf}\right)} \frac{Y_t}{\left(1-N_t^g\right) H_t}, \tag{12}$$

$$R_t = \left(1+r_t^b\right) = \left(1-\tau_t^k\right) q_t + 1 - \delta,$$

[2] The wage of an agent of group j is $w_t^j h_t$. We assume that human capital in the public and private sector is the same, only the fraction employed will differ, so that in the aggregate we will have $h_t = H_t$ and the fraction employed by the private sector is $H_t N_t^p$ and the fraction employed by the public sector is $H_t N_t^g$.

(*iii*) capital markets clear, so that aggregate capital stocks are given by

$$\begin{aligned} I_t &= i_t^p(1-N_t^g) + i_t^g N_t^g = K_{t+1} + B_{t+1}, \\ H_t &= H_t(1-N_t^g) + H_t N_t^g = H_t^p + H_t^g, \end{aligned}$$

(*iv*) commodity markets clear

$$\pi C_{t-1}^p + C_t^p + \pi C_{t-1}^g + C_t^g + K_{t+1} + I_t^G + E_t = Y_t + (1-\delta)\, K_t,$$

(*vi*) and the government budget constraint (8) holds.

3 Calibration

In this section we calibrate the model to the economy of Brazil which we consider a representative emerging country with a very generous public pension program. Brazil runs two separate pension systems for the public and the private sector. There are two constitutional provisions that guide the implementation of the public sector pension program. The requirement of "Integrality" equates pension payments to the last and highest pay check of civil servants. The provision of "Parity" indexes pensions to nominal wages paid to all civil servants.

According to Bonturi (2002) and Souza et al. (2004) the public sector pension system in Brazil accounts for 50% of all retirement payments, whereas public sector retirees only account for 5% of all retirees.[3] The average contribution rate of civil servants towards their pension fund is 11%. In the private sector the contribution rates are much higher, roughly 27% (7.6% employees contribution and 20% employer contribution) in the manufacturing and service sector. In the agricultural (rural) sector contribution rates are somewhat lower and range around 16%. The average pension paid to private sector retirees amounts to 70% to 80% of their wage income. Souza et al. (2004) report a deficit of the pension system of roughly 4.5% of GDP, 3.5% is caused by the public sector, the remaining 1% comes from the private sector. The generosity of the public sector pension system has led to concerns about its sustainability.[4]

[3] These and the following figures in this paragraph are based on data from 2001.

[4] These concerns inspired the original bill of the Constitutional Amendment 40 (Lula Reform 2003) which had two main objectives. First, it aimed at reducing the huge deficit in the civil sector pension system. Second, it aimed at making the public system more similar to the private sector system to improve equity. The changes that were actually approved fell short of the original goals and mainly affect future public servants. Souza et al. (2004) contains further details of the pension reform in Brazil.

3.1 Preferences and Technology

Table 1 reports preference and technology parameters. The discount factor is a standard one year estimate but since one period is roughly 30 years long, we scale the discount factor accordingly.

Note that for the parameters of the consumption goods technology we are imposing constant returns to scale in the two private factors. Note also that capital's share of 0.4 is large relative to the estimates reported in Gollin (2002), but this relatively large parameter value is consistent with estimates for Brazil in Elias (1992) and with values used by Barro and Sala-i-Martin (2004).

The value for the elasticity of output with respect to infrastructure capital, α_1 lies between estimates by Holtz-Eakin (1994) and Ai and Cassou (1995). For the parameter η_2 in the government technology we use a value of 0 (Cobb-Douglas production function) as the benchmark

$$G_t = Z \left(K_t^G\right)^{\frac{1}{1+\chi_2}} \left(H_t^{ui}\right)^{\frac{\chi_2}{1+\chi_2}},$$

but we will use other parameter values in our sensitivity analysis that allow for K^G and H^{ui} to be substitutes or complements. We are not aware of any estimates of η_2. We set the parameter χ_2, which measures the labor intensity of this technology, equal to unity.

We use a value of $\gamma_1 = 0.1$ for the learning elasticity with respect to public expenditure. This is consistent with an estimate by Card and Krueger (1992) and values used by Fernandez and Rogerson (1996) and by Rangazas (2000). We are also not aware of any estimates of η_1. We again use $\eta_1 = 0$ (Cobb-Douglas production function) as the benchmark

$$h_{t+1} = D \left[(H_t^{ge})^{\frac{1}{1+\chi_1}} E_t^{\frac{\chi_1}{1+\chi_1}} \right]^{\gamma_1} h_t^{\gamma_2}$$

and perform sensitivity analysis using a variety of values for η_1.

Table 2 reports the specific public policy parameters we use for the calibration exercise. The top panel in table 2 contains data on government expenditures, the second panel contains data on tax rates, while the third panel contains data on the relative size of the public and private labor force.

3.2 Government

We set public expenditures on education exclusive of teacher salaries equal to 1% of GDP. According to The Economist (Feb. 20, 2003), total public education expenditure in Brazil in 1999 was 5.1% of GDP. We subtract 25% which is spent on tertiary education, since only 2% of all students attend college, leaving us with 3.825% of GDP. We assume that about 75% of that is spent on salaries of teachers and administrators, leaving about 1% of GDP for buildings, computers, textbooks, etc.

According to Calderon, Easterly and Serven (2003), investment in infrastructure is about 1% of GDP. Wages to current civil servants amount to about 5.1% of GDP (Social Security Ministry of Brazil, 2002). According to the Ministerio de Previdencia e Assistencia Social of Brazil transfers to the old in the private sector amount to 6.6% of GDP, while public sector pensions amount to about 5% of GDP (see Souza et al. (2004)).

In our model public sector wages are higher than private sector wages by a factor ξ. We set $\xi = 1.3$ to match the size of the public sector wage bill at 4.7% of GDP.

In order to model integrality, we need a measure of wages in the last years of one's career relative to wages averaged over the entire career. We set this number $\Psi^g = 1.5$ in order to match the size of the public sector pension bill at 5.6% of GDP. As $\Psi^g > 1$ the pensions paid are actually higher than current average wages.[5]

Private pension replacement rates are considerably lower than that at $\Psi^p = 0.16$. We again set this replacement rate to match the size of private sector pension bill at 6.98% of GDP (see Souza et al. (2004)) accounting for the fact that private sector retirees comprise roughly 94% of all retirees.

Our data on tax rates is from Souza et al. (2004). The social security tax rate levied from both public sector workers is 11% of wage income. In the private sector employers add 10% of the wage bill to the pension fund.[6]

The labor income tax rate for both types of employees net of social security contributions is 11%. The capital tax rate is 15.5% resulting in tax revenue as a fraction of GDP of 35% excluding social security contribution rates.

According to the Social Security Ministry of Brazil in 2002 there are about 5.2 million civil servants in Brazil; this constitutes 6% out of a labor force of about 85 million. According to the Global Education Database, there are approximately 2.17 million teachers in Brazil. Thus we set $a = 42\%$.

4 Policy Experiments and Results

Our goal is to investigate alternative mechanisms to improve efficiency and welfare by reallocating government funds from non-productive public pensions to productive public education and infrastructure investments. In order to isolate the effects of public pension reform we conduct several policy experiments. First, we investigate the adverse effects on the intertemporal consumption-savings decision and then on capital accumulation as a whole while

[5] Since wages in the data are rising with age and in the model wages are constant over the entire period, Ψ^g and Ψ^p are actually replacement rates of average wages over the entire period. Since replacement rates for public pensions are very large in developing countries and actually replacement rates for income earnerd at higher ages, "average wage" replacement rates of $\Psi^g > 1$ shall not surprise the reader.

[6] Since our model does not account for all government expenditure, our tax rate on employers is lower than the 20% reported by (Souza et al., 2004, p. 5).

keeping taxes constant. Then, we study the effects from removing distortions of tax-financing instruments. Finally, we analyze the entire opportunity costs of generous public pensions by investing freed up resources into public education and infrastructure.

4.1 Public Pensions and Savings

In this policy experiment we report the classic result that public pension programs crowd out private savings and that pension reforms that remove these distortions improve efficiency and welfare. We call this the *"pure savings effect"*.

We calibrate our benchmark model to match the Brazilian data. Then, we introduce an unanticipated pension reform in which we reduce the generosity of public pensions Ψ^g and let government consumption Δ_{Cg} adjust to clear the government budget constraint. Government consumption is unproductive and has no further effects in our model. We keep the taxation unchanged so that all the distortionary effects from the tax originally financing the public pensions remain in place. We present the results in figures 1 and 2. We use the results of this experiment as a benchmark case.

We find that cutting the generosity of public pensions increases civil servants's savings and capital accumulation. These results are well established in the previous literature on social security. Our model generates similar results. Surprisingly, even though civil servants only make up a relatively small fraction of the labor force their savings contribution to capital accumulation is distorted significantly when the government runs a generous public pension program. Specifically, if we decrease the generosity of the pension program from $\Psi^g = 1.5$ to $\Psi^g = 1$ then the steady state output increases by up to 4% of GDP as can be seen in the top-left panels of figures 1 and 2 respectively.

The mechanism that drives this effect is described as follows. When the government cuts the generosity of public pensions, civil servants' pension incomes when old decrease. In responding to a lower stream of future incomes, civil servants save more when young in order to smooth their consumption path. Increases in civil servants' savings drives down the market interest rates, which lowers incomes of not only public sector agents but also private sector agents when old. This results in two opposing effects (income and substitution effect) for the private sector workers. On the one hand the lower interest rate increases pension transfers of private sector workers in present value terms, which will reduce savings of private sector agents. Also, the lower interest rate makes saving less attractive (price effect). Increases in capital stock from public sector savings increases on the other hand lead to increases in income of private sector agents, which in turn allows private sector agents to save more (income effect). All in all the positive savings effects dominate (income effect outweighs the substitution effect), so that we observe an increase in the capital stock and output. Hence, the general equilibrium mechanism passes the saving effects on to private sector agents, who make up more than 90 percent of the population. This policy reform, which first has affected

only a small fraction of population, turns out to be significantly larger in the long run when all the general equilibrium effects are accounted for.

4.2 Public Pensions vs. Taxation

In this policy experiment we investigate the effects from reducing the distortionary effects of tax-financing instruments. In our policy reform we again decrease the generosity of public pensions Ψ^g and let taxes adjust to clear the government budget. Since the government does not have to finance large public pension program anymore, taxes can be reduced. As a consequence the labor tax or the capital tax rate can be cut by up to 5 basis points which ameliorates tax distortions in the economy and improves efficiency.

We first adjust labor taxes τ_L and report the results in figure 1. As the replacement rate for public pensions Ψ^g drops from 1.5 to 1, and τ_L adjusts downwards, output increases by about 15%. The mechanism that leads to this result can be described as follows. First, there is a positive savings effect on civil servants due to the reduction of their expected future pension payments. This effect is captured when letting government consumption Δ_{Cg} adjust to clear the government budget constraint. We plot this *"pure savings effect"* as a dotted line in figure 1. This effect turns out to explain roughly one third of the output change in the previous section. Second, since taxes adjust to clear the government budget constraint there is another effect in play that we call the *"tax effect"*. As the young are the only savers in the model, increasing their after tax income increases savings, capital accumulation and steady state income. This effect is reinforced by a simultaneous drop in the real interest rate, which lowers debt service and allows a further reduction in the labor income tax rate. This additional reduction in the tax rate further stimulates capital accumulation and increases steady state income.

There are two sources of efficiency gains resulting from this policy reform: first, decreasing the generosity of public pension reduces the adverse effects on savings, the *"pure savings effect"*; and second, lower tax rates decrease tax distortions, the *"tax effect"*. We find that these two effects together cause the large increase of steady state output of close to 15% of GDP when the replacement rate is reduced all the way down to $\Psi^g = 1$.[7]

We also let capital taxes adjust in reaction to the cuts in public pensions from $\Psi^g = 1.5$ to 1. The results for capital tax adjusting are qualitatively identical but quantitatively smaller. An adjustment of τ_K has a smaller effect on output of roughly 4% when Ψ^g declines from 1.5 to 1. It is interesting to see that when capital taxes adjust there is virtually no output difference to the case where capital taxes are unchanged. In our model tax distortions from

[7] In addition to the steady state equilibrium depicted in figure 1 there is a second type of steady state equilibrium in which a decrease of Ψ causes the interest rate R and the labor tax rate τ_L to rise. An increase in R is then consistent with lower savings, lower investment and hence higher marginal product of capital such that the government budget constraint is still satisfied. All these together result in a decrease of steady state output.

capital taxes only play a minor role, whereas tax distortions from labor taxes have large effects. The reason is that the channels of effects when capital taxes adjust are different. When letting labor taxes adjust the policy reform increases labor incomes when young and reduces pension incomes when old. In response, civil servants save more when young in order to smooth their consumption path, which then drives down the market interest rates. Increases in income due to lower labor taxes and decreases in the market interest rates induce agents to accumulate more capital stocks.

When letting capital taxes adjust the pension policy reforms affect not only agent's incomes but also the market interest rates directly. As capital tax rates drop the after tax interest rates increase substantially (see panel 5 of figure 1). Increases in the net interest rates induce agents to save less. The effect on capital accumulation is mitigated. This channel of effects is absent when labor taxes adjust. As a results, efficiency gain is substantially smaller.

4.3 Public Pensions vs. Public Education and Investment

In this experiment we identify the effects on efficiency and welfare by reallocating government funds from non-productive public pensions to productive public uses. That is, we use the newly available government revenue from making public pensions less generous to finance increases in public education expenditures and public investment, while keeping taxes unchanged. The *"pure saving effect"* is still in play. However, we shut off the "*tax effect"* by keeping all distortive effects of the financing instruments unchanged. Besides, we introduce a new channel of effects, an *"opportunity cost effect"* of being able to use the released public funds for more material inputs into education or infrastructure.

We again reduce the replacement rate of public sector pensions Ψ^g from 1.5 to 1 and use the extra funds to invest in either public infrastructure or public education. We report the results in figure 2. These policy reforms again result in efficiency gains. Steady state GDP increases by 10% when using the extra funds for public infrastructure. The intuition is a follows. Decreasing Ψ^g increases savings by public sector workers, which in turn increases steady state capital and output. In addition, increases in public sector capital make both private capital and private human capital more productive. If, on the other hand, the extra funds are used for investments into public education, the results are qualitatively and quantitatively very similar (see figure 2). That is, higher investments in public education increases the steady state level of human capital, hence the rate of return on savings, which again increases the capital stock and steady state GDP.

In the first experiment we show that these effects via savings are relatively small. Now when we use the extra revenue to fund higher education or infrastructure the total effects are sizable and more than double the original savings effect. The additional efficiency gains between this and the first policy experiment is an estimate of the *"opportunity cost effect"* which in our experiment is responsible for an increase of GDP of up to 6%.

4.4 Welfare Analysis

In order to conduct welfare analysis we calculate transitions between the original steady state with a compensation ratio of $\Psi^g = 1.5$ and the new steady state with ratio $\Psi^g = 1$. It takes roughly fifteen periods for the transition to be complete which is a rather long time given that one period accounts for roughly 30 years. Transitions for all experiments are smooth and monotone.

We then calculate the compensating consumption levels per age cohort that make agents indifferent between the benchmark case $\Psi^g = 1.5$ and the new regime with $\Psi^g = 1$. Figures 3, 4 and 5 report compensating consumption levels for the three policy experiments that we concentrate on, that is (i) capital taxes adjust, (ii) public capital investments adjust and (iii) investments into public education adjust.

We first record the present value welfare levels of each cohort over the transition period for the case without a policy change. Second, we record welfare levels for each cohort when the government administers a change in the pension compensation scheme of civil servants. We then calculate the average per period compensating consumption for each generation that equalizes their respective lifetime welfare.

In all three figures we illustrate the average percentage of current value compensating consumption over current value consumption for each age cohort. We distinguish between private (circles), public (triangles) and aggregate (x's) welfare levels.

For case (i) and (iii) we see that civil servant generations that are born before the policy change benefit from it because of grandfathering (compare generation 0 in figures 3 and 4). Private sector workers of generation 0 lose from the reform. There are two effects at work here. When the policy reform is announced generation zero agents enter their second (or old age) period. Due to the higher savings of the new public cohorts, the interest rate drops, so that the savings income of old agents decreases. At the same time wages increase. Since pensions are indexed to current wages, the pension income of private sector retirees increases. Since the replacement rate in the private sector is fairly low, the pension increase is not enough to offset the loss from savings income. Therefore, private sector workers of generation 0 lose from the pension reform. This happens when capital taxes or public capital investments adjust as a reaction to the public pension cuts.

All future private sector generations will benefit from the reform. All future public sector generations will lose from the reform.

The fact that current private sector workers suffer welfare losses from the reform has important implications for implementing such welfare reform. Only when there is a majority of the currently alive that benefits from the reform, can we expect such reforms to be implemented. In our case the long run gains from such reforms are not shared with current generation workers, so that reform success seems unlikely unless current generations can be compensated with payments that borrow against increased payoffs to future generations.

5 Sensitivity Analysis

In this section we investigate the magnitude of our results under alternative technology specifications.

Human capital production function. The size of the efficiency gains of the public policy reform depends on γ_1 the elasticity of human capital (learning) and public education inputs. In the following we rerun the following policy experiment: reduce the generosity of public pensions and let investments into public education increase to clear the government budget constraint. We then repeat this experiment for various values of technology parameter $\gamma_1 \in [0.05;\ 0.15]$ (benchmark is 0.1) and summarize the results in table 4. As we decrease the generosity of public pensions from $\Psi^g = 1.5$ to $\Psi^g = 1$ steady state output increases by 10% in the benchmark case. If parameter γ_1 is increased to 0.15 then the output effect is even larger (15% of GDP) since now the freed up resources are invested in public education which becomes more and more productive as γ_1 increases.

Little is known in the literature on empirical education production functions and about the elasticity of substitution between teachers and material education inputs, parameter η_1. In table 5 we illustrate how shifting public funds from public sector pensions to education depends upon η_1, the (inverse of the) elasticity of substitution in the education production function. We see from table 5 that our results are relatively sensitive to changes in η_1. In the benchmark case we set $\eta_1 = 0$ (Cobb-Douglas case) and found a 10% output effect. This is an upper limit, since larger values of η_1 (CES production function) result in smaller output changes. If $\eta_1 = 1$ (linear case), the output effect of an otherwise identical policy reform decreased from 10% to 4% of GDP.

Final goods and services production function. In table 6 we show how sensitive the results are with respect to changes in α_1, the elasticity of output with respect to public capital. In this experiment we let investments into infrastructure (public good) adjust to clear the government budget constraint after the policy reform. We allow α_1 to vary from 0.05 to 0.15, (0.1 is the benchmark case according to estimates in Holtz-Eakin (1994) and Ai and Cassou (1995)). For this range of parameter values reducing Ψ^g from 1.5 to 1 increases steady state output between 7% and 15%. Thus, for realistic parameter values the effects of reallocating funds to public investment can be enormous. The larger α_1 the more output increases from additional investments in infrastructure.

Public capital production function.

In table 7 we again compare how shifting public funds from public sector pensions into public sector capital depends on η_2,the elasticity of substitution in the public goods production function. Note that if $\eta_2 > 0$ then public capital and public sector human capital (labor) are substitutes whereas for $\eta_2 < 0$ public capital and labor are complements. The effects on steady state income of using the extra revenue from public sector pensions for investment

in infrastructure are quite sensitive to changes in η_2 and significantly larger if public capital and public sector human capital are complements. As η_2 increases (public capital and public sector human capital become substitutes), the effect on output declines.

Total factor productivity

Given the paucity of estimates of TFP in multi-sector models we decided to use Cobb-Douglas production functions in our benchmark economy. With Cobb-Douglas production functions the relative size of total factor productivities (TFPs, $A = Z = D = 1$) is irrelevant and has no effect on the quantitative results of our experiments. Only if production functions producing human capital and the public good are not of the Cobb-Douglas type, do TFPs affect the experiments quantitatively, but even then our results are robust to changes in TFPs.

6 Conclusion

In this paper we have used an overlapping generations model to assess the efficiency gains of re-allocating government funds from unproductive public pensions to productive investments into public education and infrastructure. We have calibrated the model to Brazil and provided extensive sensitivity analysis. We found that (i) the direct effects of pension reform through savings of civil servants are small, (ii) the effects from reducing tax distortions are large at up to 15% of GDP, and (iii) the indirect effects from reinvesting freed up resources into public education or infrastructure are also substantial at up to 10% of GDP.

Implementing a policy reform that severely restricts the generosity of public sector pensions is bound to run into strong political opposition since civil servants are typically well organized. While the long run costs of very generous pensions and the long run gains from pension reform are clear and well documented in the literature, it is crucial to find a way to overcome short run political opposition. Our model clearly shows that the policy reform results in substantial welfare losses in the current generation of private sector retirees. These workers will see a decrease in interest income since the increase in capital accumulation will lower the interest rate on their savings. These welfare losses will most likely lead to political opposition and doom any attempts at meaningful reform. Only future generations of private sector workers stand to gain from the reform as they benefit fully from the higher productivity level of the post reform economy. We expect such a result to hold in other countries in Latin America and beyond. This result should also hold if population growth and aging of the population is taken into consideration.

In this paper we have concentrated on three channels of how public sector pension reform might influence capital accumulation. Additional channels might be: (i) The generosity of public sector pensions influences workers' retirement decisions, which in turn has an effect on GDP. (ii) The generosity of public sector pensions relative to pensions in the private sector

will influence how workers will be allocated across both sectors, which in turn will influence GDP. This would require the introduction of heterogenous agents who make idiosyncratic investment choices into their human capital. This extended framework would allow us to investigate changes in the quality of the public sector labor force, given a specific worker compensation package (wages plus pension plan).

In our model the publicly produced service was made available to all firms and households at a zero price. While this might be a useful assumption for the provision of infrastructure like roads and highways, it clearly does not cover all relevant cases. When governments produce goods like telecommunication services or electricity, they typically charge for these goods/services. Prices charged need not bear any particular relationship to marginal or average costs. This will impact the government budget constraint. We leave the exploration of these channels for future research.

References

Ai, Chunrong and Stephen P. Cassou. 1995. "A Normative Analysis of Public Capital." *Applied Economics* 27:1201–1209.

Aschauer, David A. 1998. "How Big Should the Public Capital Stock Be? The Relationship between Public Capital and Economic Growth." The Jerome Levy Economics Institute of Bard College, Public Policy Brief No. 43.

Auerbach, J. Alan and Laurence J. Kotlikoff. 1987. *Dynamic Fiscal Policy*. Cambridge University Press.

Barro, Robert J. 1990. "Government Spending in a Simple Model of Endogenous Growth." *Journal of Political Economy* 98(5):S103–S125.

Barro, Robert J. and Xavier Sala-i-Martin. 2004. *Economic Growth*. second ed. Cambridge: The MIT Press.

Benabou, Roland. 1996. "Heterogeneity, Stratification, and Growth: Macroeconomic Implications ofCommunity Structure and School Finance." *The American Economic Review* 86(3):584–609.

Blankenau, William F. and Nicole B. Simpson. 2004. "Public Education Expenditures and Growth." *Journal of Development Economics* 73:583–605.

Bonturi, Marcos. 2002. "The Brazilian Pension System: Recent Reforms and Challenges Ahead." OECD Economics Department Working Paper No. 340.

Bresser-Pereira, C. Luiz. 1990. The Perverse Macroeconomics of Debt, Deficit and Inflation in Brazil. In *Perspectives on the Pacific Basin Economy: A Comparison of Asia and LatinAmerica*, ed. Fukuchi T. and M. Kagami. Toquio: Institute of Developing Economies.

Calderon, Cesar, William Easterly and Luis Serven. 2003. Latin America's Infrastructure in the Era of Macroeconomic Crises. In *The Limits of Stabilization Infrastructure, Public Deficits and Growth inLatinAmerica*, ed. W. Easterly and L.Serven. Washington, DC: World Bank.

Calderon, Cesar, William Easterly and Luis Serven. 2003. *Latin America's Infrastructure in the Era of Macroeconomic Crisis*. Washington, D.C.: The World Bank.

Card, David and Alan B. Krueger. 1992. "Does School Quality Matter? Returns to Education and the Characteristicsof Public Schools in the United States." *Journal of Political Economy* 100:1–40.

Cassou, Steven P. and Kevin J. Lansing. 1998. "Optimal Fiscal Policy, Public Capital, and the Productivity Slowdown." *Journal of Economics Dynamics and Control* 22(6):911–935.

Diamond, Peter A. 1965. "National Debt in a Neoclassical Growth Model." *American Economic Review* 60:1126–1150.

Elias, V. 1992. *Sources of Growth: A Study of Seven Latin American Economies*. ICS Press, San Francisco.

Fernandez, Raquel and Richard Rogerson. 1996. "Income Distribution, Communities and the Quality of Public Education." *Quarterly Journal of Economics* 111:135–164.

Fernandez, Raquel and Richard Rogerson. 1998. "Public Education and Income Distribution: A Dynamic Quantitative Evaluationof Education-Finance Reform." *American Economic Review* 88(4):813–833.

Ferreira, Pedro Cavalcanti and Leandro Goncalves do Nascimento. 2005. "Welfare and Growth Effects of Alternative Fiscal Rules for InfrastructureInvestment in Brazil." Manuscript, EPGE - FGV(604).

Ferreira, Sergio G. 2005. "Pension Reform in Brazil: Transitional Issues in a Model with Endogenous Labor Supply." IBMEC Economics Discussion Paper 2005-02.

Foguel, Miguel N., Indermit Gill, Rosane Mendonca and Ricardo PaesdeBarros. 2000. "The Public-Private Wage Gap in Brazil." Discussion Paper No. 754, Instituto de Pesquisa Econômica Aplicada (IPEA).

Glomm, Gerhard and B. Ravikumar. 1994. "Public Investment in Infrastructure in a Simple Growth Model." *Journal of Economic Dynamics and Control* 18(6):1173–1187.

Glomm, Gerhard, Juergen Jung and Chung Tran. 2006. "Macroeconomic Implications of Early Retirement in the Public Sector: The Case of Brazil." CAER Working Papers 2006-008.

Gollin, Douglas. 2002. "Getting Income Shares Right." *Journal of Political Economy* 110(2):458–474.

Holtz-Eakin, Douglas. 1994. "Public Sector Capital and the Productivity Puzzle." *Review of Economics and Statistics* 76(1):12–21.

Hulten, Charles B. 1996. "Infrastructure Capital and Economic Growth: How well you use it may be moreimortant than how much you have." NBER Working Paper No. 5847.

Loury, Glenn C. 1981. "Intergenerational Transfers and the Distribution of Earnings." *Econometrica* 49(4):843–867.

OECD. 2005. *OECD Economic Surveys, Brazil - Volume 2005 Issue 2*. OECD Publishing.
URL: *http://www.oecd.org/document/60/0,2340,en*$_2$649$_3$4571$_3$4413308$_{1111}$,00.*html*

Palacios, Robert and Edward Whitehouse. 2006. "Civil-service Pension Schemes Around the World." Social Protection (SP) Discussion Paper No. 0602, The World Bank.

Panizza, Ugo. 2000. "The Public Sector Premium and the Gender Gap in Latin America: Evidence for the 1980s and 1990s." Working Paper 431, Inter-American Development Bank.

Panizza, Ugo. 2001. "Public Sector Wages and Bureaucratic Quality: Evidence from Latin America." *ECONOMIA* Fall:97–151.

Panizza, Ugo and Christine Zhen-Wei Qiang. 2005. "Public Private Wage Differential and Gender Gap in Latin America: Spoiled Bureaucrats and Exploited Women?" *The Journal of Socio-Economics* 34:810–833.

Rangazas, Peter. 2000. "Schooling and Economic Growth: A King-Rebelo Experiment with Human Capital." *Journal of Monetary Economics* 46:346–416.

Rogoff, Kenneth. 2005. "Strategies for Bringing Down Long-Term Real Interest Rates in Brazil." Presentation at Central Bank of Brazil, August 30.
URL: *www.bcb.gov.br/Pec/SemMetInf2005/Port/Rogoff.pdf*

Souza, Andre Portela, Helio Zylberstajn, Luis Eduardo Afonso and PriscillaMatia Flori. 2004. "Fiscal Impacts of Social Securty Reform in Brazil." Working Paper.

Souza-Sobrinho, Nelson F. 2004. "Structural Reforms and Economic Performance: Brazil in the 1990s." UCLA.

Turnovsky, Stephen J. and Walther H. Fisher. 1995. "The Composition of Government Expenditure and Its Consequences for MacroeconomicPerformance." *Journal of Economic Dynamics and Control* 19(4):747–786.

7 Appendix B: Tables and Graphs

Parameters		
Preferences		
Inverse of Intertemporal Elasticity of Substitution	$\sigma = 1.5$	to match R and K/Y
Discount factor	$\beta = 0.98^{30}$	to match R and K/Y
	$\pi = 0.8$	to match share of older population
Technology		
Consumption Good:		
	$A = 1$	Normalization
	$\alpha_1 = 0.1$	Hulten (1996)
	$\alpha_2 = 0.4$	Ferreira and do Nascimento (2005)
	$\alpha_3 = 0.6$	$\alpha_2 + \alpha_3 = 1$
	$\delta = 1$	complete depreciation over 30 year period
Public Good:		
	$Z = 1$	Normalization
	$\chi_2 = 1$	Sensitivity analysis
	$\eta_2 = 0$	Cobb-Douglas
	$\delta_G = 0.65$	to match $\frac{K_g}{K}$
Human Capital:		
	$D = 1$	Normalization
	$\chi_1 = 0.2$	Sensitivity analysis
	$\eta_1 = 0$	Cobb-Douglas
	$\gamma_1 = 0.1$	Card and Krueger (1992)
	$\gamma_2 = 0.5$	Sensitivity analysis

Table 1: Preference and Technology Parameters

Variables for Benchmark Case:		Source
Policies:		
Investment in public good (in % of private sector output)	$\Delta_G = 2.5\%$	Calderon and Serven (2003) report 2.5%
Public Education: Teacher's Salary (in % of private sector output)	$\Delta_E = 1\%$	Sensitivity analysis
Government residual expenditure (in % of private sector output)	$\Delta_{Cg} = 7\%$	to fix total tax revenue at 35% of GDP Immervoll et al. (2006)
Debt level	$\Delta_B = 3\%$	to match debt level of 36% of GDP reported in Ferreira (2005)
Public wages as a fraction of private wages	$\xi = 1.35$	Foguel et al. (2000), to match public wage bill
Indexation parameter (generosity of private pensions)	$\Psi^p = 0.16$	Based on Bonturi (2002), to match private pension bill
Indexation parameter (generosity of public pensions)	$\Psi^g = 1.5$	Integrality, to match public pension bill
Taxes:		
Labor tax rate (net of social security)	$\tau_L^p = \tau_L^g = 15.4\%$	Ferreira and do Nascimento (2005)
capital tax rate,with bonds	$\tau_K = 15.5\%$	Immervoll et al.(2006)
social security contribution rate of civil servants	$\tau_L^{ssg} = 11\%$	Immervoll et al. (2006) and authors' own calculation
social security contribution rate of private sector employees	$\tau_L^{ssp} = 11\%$	Immervoll et al. (2006) and authors' own calculation
social security contribution rate of private sector employers	$\tau_L^{sspf} = 10\%$	Immervoll et al. (2006) and authors' own calculation
Labor:		
fraction of civil servants	$N^g = 6\%$	Social Security Ministry of Brazil (2002)
private sector employees	$N^p = 94\%$	
fraction of teachers in public sector	$a = 42\%$	

Table 2: Government Policy Parameters

Variables for Benchmark	Model	Data	Source
Capital output ratio	$\frac{K}{Y} = 2.9$	2.6	Bresser-Pereira (1990) and Souza-Sobrinho (2004)
Interest rate	$R = 4.25\%$	9.6%	Rogoff (2005)
Public capital to private capital ratio	$\frac{K_g}{K} = 40\%$	44.6%	Aschauer (1998) reports 44.6% for the U.S.
Government Size:			
Tax revenue (in % of private sector output)	35.3%	35%	Immervoll et al. (2006) report 35% of GDP.
Expenditures:			
Wage bill public sector workers (in % of private sector output)	$\frac{\xi w H N^g}{Y} = 4.7\%$	5.1%	Social Security Ministry of Brazil (2002) and authors' calculation
Public pensions (in % of private sector output)	$\frac{\Psi^g \xi w H N^g}{Y} = 5.6\%$	5%	Souza et al. (2004) report 5% of GDP.
Private pensions (in % of private sector output)	$\frac{\Psi^p w H N^p}{Y} = 6.98\%$	6.6%	Souza et al. (2004) report 6.6% of GDP.

Table 3: Model Outcomes that Match Brazilian Data

	Ψ	1	1.25	1.5	1.6
	0.050	106.531	103.601	100.000	97.876
	0.060	107.201	104.019	100.000	97.555
	0.070	107.909	104.458	100.000	97.219
	0.080	108.658	104.922	100.000	96.867
	0.090	109.449	105.410	100.000	96.500
γ_1	0.100	110.288	105.927	100.000	96.114
	0.110	111.180	106.474	100.000	95.710
	0.120	112.127	107.054	100.000	95.286
	0.130	113.137	107.670	100.000	94.840
	0.140	114.214	108.326	100.000	94.370
	0.150	115.368	109.025	100.000	93.874

Table 4: Change in Output with Δ_E adjusting ($\eta_2 = 0.5$)

	Ψ	1	1.25	1.5	1.6
	0.000	110.289	105.926	100.000	96.114
	0.250	107.178	103.889	100.000	97.910
η_1	0.500	105.462	102.809	100.000	98.731
	0.750	104.570	102.278	100.000	99.073
	1.000	104.114	102.023	100.000	99.209

Table 5: Change in Output with Δ_E adjusting

	Ψ	1	1.25	1.5	1.6
	0.050	106.837	103.612	100.000	98.345
	0.060	107.563	104.018	100.000	98.138
	0.070	108.309	104.434	100.000	97.928
	0.080	109.072	104.860	100.000	97.714
	0.090	109.857	105.296	100.000	97.496
α_1	0.100	110.664	105.743	100.000	97.275
	0.110	111.493	106.201	100.000	97.049
	0.120	112.345	106.669	100.000	96.820
	0.130	113.221	107.150	100.000	96.586
	0.140	114.123	107.642	100.000	96.349
	0.150	115.050	108.147	100.000	96.107

Table 6: Change in Output with Δ_G adjusting ($\eta_2 = 0.5$)

	Ψ	1	1.25	1.5	1.6
	-1.000	118.052	109.930	100.000	95.148
	-0.750	116.920	109.336	100.000	95.394
	-0.500	115.333	108.456	100.000	95.812
η_2	-0.250	113.350	107.312	100.000	96.417
	0.000	110.664	105.744	100.000	97.274
	0.250	109.136	104.815	100.000	97.822
	0.500	107.429	103.812	100.000	98.373

Table 7: Change in Output with Δ_G adjusting

.

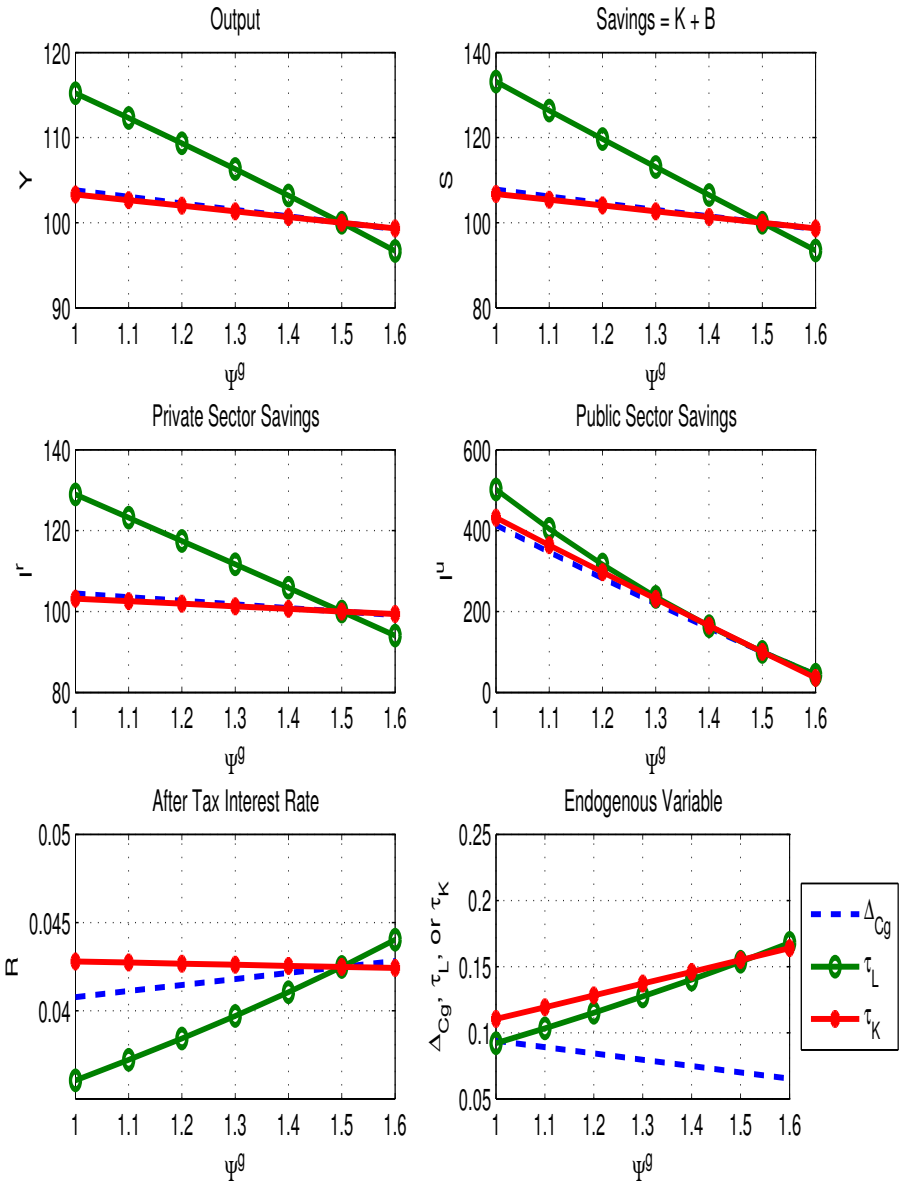

Figure 1: Effect of decreasing public sector pensions Ψ^g and decreasing labor taxes τ_L or capital taxes τ_K

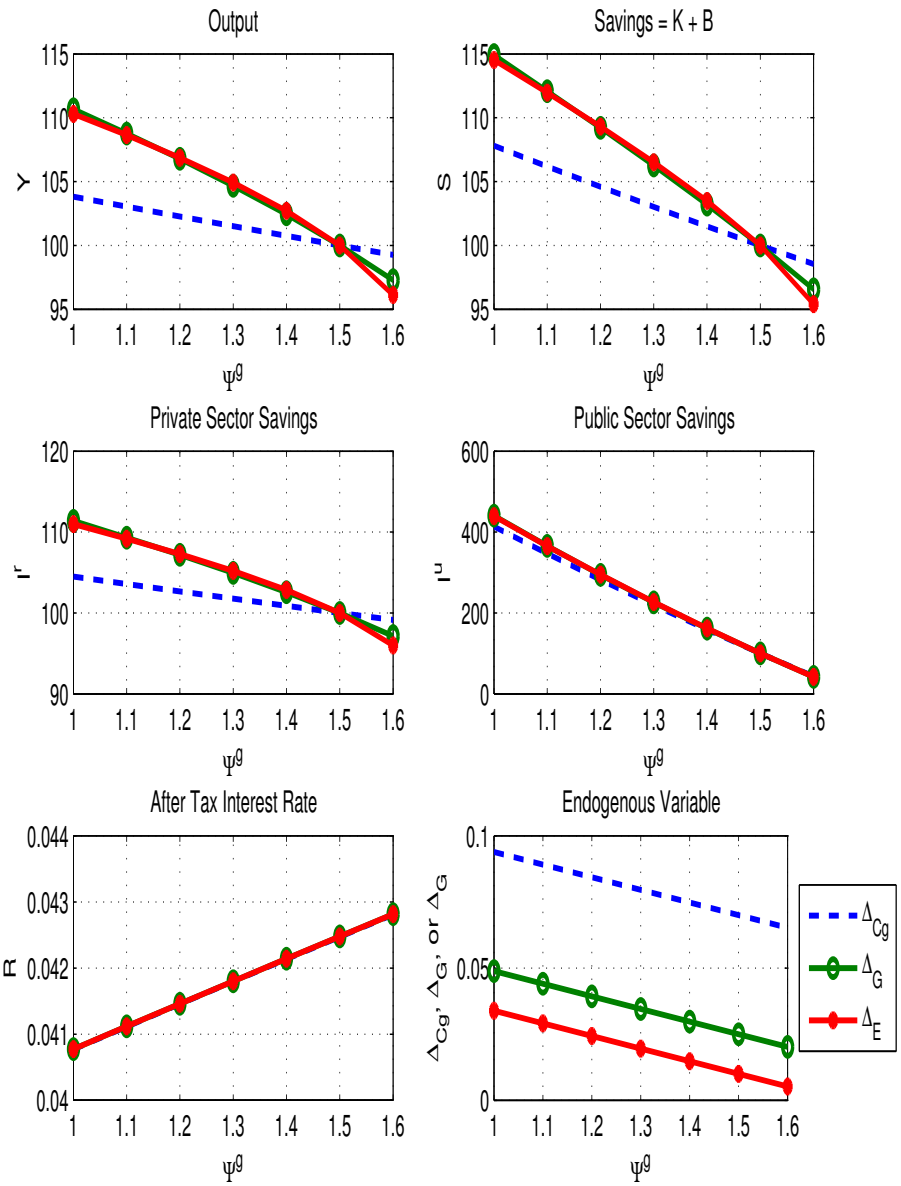

Figure 2: Effect of decreasing public sector pensions Ψ^g and increasing public investment Δ_G or public education Δ_E

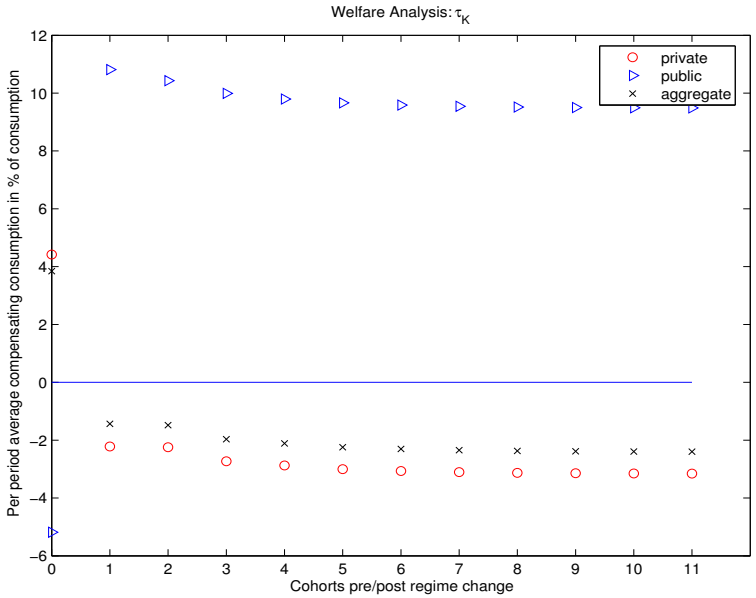

Figure 3: Compensating consumption given to individuals to offset the policy change that reduces the generosity of public pension replacement rate $\Psi^g = 1.5$ to $\Psi^g = 1.0$ letting capital tax τ_K adjust to clear the government budget constraint. Compensating consumption is expressed as the average percentage of current value per period compensating consumption over current value consumption.

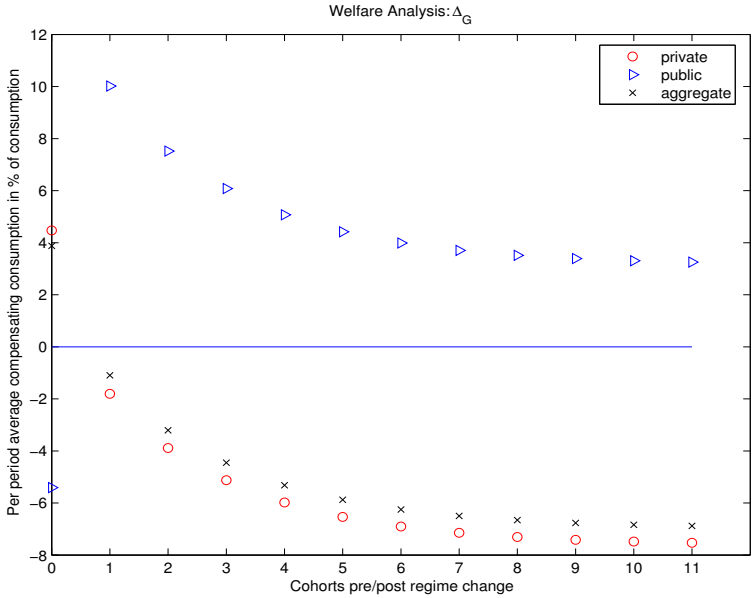

Figure 4: Compensating consumption given to individuals to offset the policy change that reduces the generosity of public pension replacement rate $\Psi^g = 1.5$ to $\Psi^g = 1.0$ letting investments into public capital Δ_G adjust to clear the government budget constraint. Compensating consumption is expressed as the average percentage of current value per period compensating consumption over current value consumption.

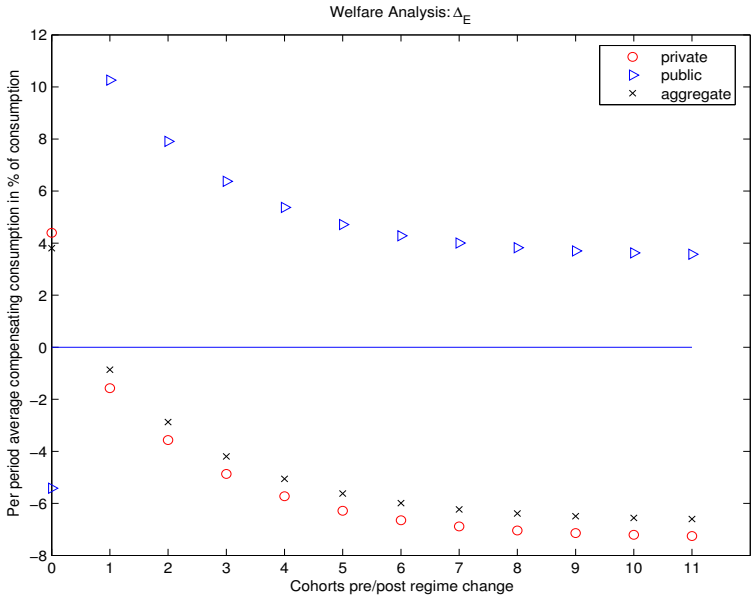

Figure 5: Compensating consumption given to individuals to offset the policy change that reduces the generosity of public pension replacement rate $\Psi^g = 1.5$ to $\Psi^g = 1.0$ letting public education expenditures Δ_E adjust to clear the government budget constraint. Compensating consumption is expressed as the average percentage of current value per period compensating consumption over current value consumption.